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~~One of the volumes of~~ a study which was conducted for the purpose of defining the air pollution problems of the iron foundry industry and of setting priorities for research and development activities that will lead to improved emission control capabilities at reduced cost. ~~This volume~~ consists of the following appendices: Bibliography, Data bank, material and heat balance of foundry melting furnances, Detail Economic Cost Curves, Emission Test Procedure, and Glossary of terms. Volume I contains the text, and Volume II contains exhibits.

The report

for

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SYSTEMS ANALYSIS OF EMISSIONS AND EMISSIONS CONTROL IN THE IRON FOUNDRY INDUSTRY

VOLUME III - APPENDIX

FEBRUARY, 1971

For

Division of Process Control Engineering
Air Pollution Control Office
Environmental Protection Agency

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Chicago, Illinois

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AIR POLLUTION CONTROL OFFICE

SYSTEMS ANALYSIS OF EMISSIONS AND EMISSIONS CONTROL IN THE IRON FOUNDRY INDUSTRY

VOLUME III - APPENDIX
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American Association for the Advancement of Science
American Conference of Governmental Industrial Hygienists
American Foundrymen's Society
American Coke and Coal Chemicals Institute
American Industrial Hygiene Association
American Institute of Mining, Metallurgical, and Petroleum Engineers
American Iron and Steel Institute
American Petroleum Institute
American Society of Mechanical Engineers
American Society for Testing and Materials
American Society of Civil Engineers
Battelle Memorial Institute
Bay Area Air Pollution Control District, San Francisco
British Cast Iron Research Association
Center for Air Environmental Studies - Pennsylvania State Univ.
Graphic Arts Technical Foundation - Pittsburgh
Gray and Ductile Iron Founders' Society
Industrial Gas Cleaning Institute
Iron and Steel Institute
Los Angeles County Air Pollution Control District
Malleable Founders' Society
Manufacturing Chemists' Association
National Air Pollution Control Association
National Pollution Control Foundation
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Research-Cottrell, Inc.
U.S. Bureau of Mines

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ASM Review of Metals Literature

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Index to Air Pollution Research... Center for Air Environmental Studies, Pennsylvania State University

Pollution Control Manual and Directory

U.S. Government Research & Development Reports Index

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Mill and Factory
Mining Congress Journal
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Pollution Engineering
Pollution Equipment News
Power
Power Engineering
Przeglad Odlewnictwa (Polish)
Product Engineering

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Radex Rundschau (German)
Roads and Streets
Rock Products
Russian Castings Production (English Translation of Liteinoe Proizvodstvo)
Safety Maintenance
Sangyo Kogai (Japanese)
Science and Technology
Smoke Prevention Association of America Proceedings
Smokeless Air
Soviet Powder Metallurgy and Metal Ceramics
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APPENDIX B

DATA BANK

All the data compiled on the foundries are contained in the data bank which is a part of this appendix. The actual listing of the data is given in Exhibit I of this appendix.

Exhibit I is divided into six sections with each section dealing with a different aspect of the foundry data. Each section begins with the foundry identification number and this number, therefore, provides the key between sections when obtaining additional data listed for that foundry number.

If a foundry number is omitted in a section it can be assumed that the data was not available or did not apply as the case may be.

The headings for each section which describe the data fields are, for the most part, abbreviations. A listing of the abbreviations and the appropriate descriptions are given in the Format for the Data Bank, Exhibit II of this appendix. The format for the data bank is arranged in sections which correspond to the sections of the data bank, Exhibit I.

In several cases the data is provided as coded input. The explanation of the code is given after the appropriate description of the abbreviated heading in Exhibit II.

APPENDIX B
EXHIBIT I
SECTION I PAGE 1

```
                                                 GENERAL  FOUNDRY  DATA

FDRY CO LOC MET PERCENT CAST TON/MONTH MELT   SIZ IND WT PRO NOD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST GI  MI  DI    GI   MI     DI  CLA CLA RG CST     T LB T LB T LB 1 LB 2 LB REP FCE TAP      MOLD      EERP ATK
0001 01 362  1  100 030 000       00000 00000  4   3      2   0
0002 01 902  1  100 030 000       00000 00000  3   3      2   0                                                       1
0003 01 782  1  100 000 000       00000 00000  3              0                                                       1
0004 01 492  2  000 100 000 00000 19000 00000  4   1  2   5   0  0 00 0 00 0 00 3 .1 0 00  1   1   1    3   2    2        1
0005 01 918  1  100 030 000   375 00000 00000  3   6  5       0                                                       1
0006 01 212  1  100 030 000                    3              0
0007 01 606  1  100 030 000  3200 00000 00000  3   7  2   4   0  0 00 0 00 0 00 0 00 0     0   0   1    2   1    2    1   1
0008 01 802  1  100 030 000   950 00000 00000  2   7  2   4   0  0 00 0 00 0 00 0 00 0     0   0   1    2   1    2    1   1
0009 01 074  1  100 030 000  3300 00000 00000  4              0                                                       1
0010 01 641  1  100 000 000       00000 00000  3              0
0011 01 917  1  100 030 000  1500 00000 00000  3              0                                                       1
0012 01 352  5   60 030  40 18000 00000 12000  4   3  6   2   1  3 90 4 54 5 90 1          0   0   :    3   1    3    1   1
0013 01 482  1  100 000 000       00000 00000  3              0                                                       1
0014 01 070  1  100 030 000       00000 00000                 0
0015 01 441  1  100 000 000   210 00000 00000  3      5       0                                                       1   1
0016 01 130  1  100 030 000  3000 00000 00000  3              0                                                       1
0017 01 948  5      030             00000          4  3   3   1
0018 01 631  5      030             00000        2   4  5   3                                                           1
0019 01 534  2  000 100 000 00000       00000  4              0
0020 01 138  1  100 000 000       00000 00000  2              0                                                       1
0021 01 532  5   20 000  80  1500 00000  5000  3   3  2   8   1  4  3 6 48      1          1   1   1    3   2    1        1
0022 01 541  1  100 030 000       00000 00000  4   5  4   6   0                                                       1
0023 01 029  1  100 000 000       00000 00000  3              0
0024 01 482  1  100 000 000       00000 00000  4              0
0025 01 492  1  100 030 000       00000 00000  3   4  5       0
```

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                                                        GENERAL  FOUNDRY  DATA                                  PAGE    2
FDRY CO LOC MET PERCENT CAST  TON/MONTH MELT   SIZ IND WT PRO NOD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST  GI  MI  DI   GI     MI    DI  CLA CLA RG CST     T LB T LB T LB 1 LB 2 LB REP FCE TAP      MOLD      EERP ATK

0026 01 070  1  100 030 000   1500 00000 00000  3   6  6   9   0  7  3 0 00 0 00 0 00 0 00  0   0   1        1             1

0027 01 494  1  100 030 000   2000 00000 00000  3   1  3       0  0 00 0 00 0 00 0 00 0 00  0   0   1    3   2    3        1

0028 01 802  1  100 000 000        00000 00000  2                                                                      1

0029 01 489  1  100 030 000   4000 00000 00000  4   1  6   1   0  4 30 0 00 0 00 0 00 0 00  0   0   1    2   1    2        1

0030 01 631  1  100 000 000        00000 00000                 0                                                       1

0031 01 282  1  100 030 000        00000 00000  4   3          0  0 00 0 00 0 00 0 00 0

0032 01 606  2  000 100 000  00000  2500 00000  4   6  6   4   0  0 00 0 00 0 00 2  3 9 00  0   0   1    2   1    3        1

0033 01 482  5   90 030  10        00000        4   1      5   1                                                       1

0034 01 462  1  100 000 000        00000 00000  4   1      5   0                                                       1

0035 01 452  5   92 030   8   1900 00000   160  4   4  6   5   1  1 12 2 45      0 00 0     0   0   1    2   1    2    1   1

0036 01 900  1  100 030 000    120 00000 00000  2              0                                                       1

0037 01 902  1  100 030 000    160 00000 00000  2              0                            0   0                      1

0038 01 606  1  100 030 000        00000 00000  4   5      6   0                                                       1

0039 01 374  1  100 030 000        00000 00000  4   5      6   0

0040 01 016  1  100 000 000        00000 00000  3              0                                                       1

0041 01 902  5      030            00000        3      5       1

0042 01 465  7   76  21   3   4400  1200   200  4   6  6       1  4  2 7  2                 1   1   1    3   1    3        1

0043 01 467  1  100 030 000    500 00000 00000  3   4  2   3   0                            0   0   1    2   1    2        1

0044 01 520  1  100 030 000        00000 00000  4   2      7   0

0045 01 507  5      000            00000        4   2      7   1                                                       1

0046 01 612  5   21 030  79   1600 00000  6000  4   2  6   7   1  3  8 4  6                 1   4   1    2   2    1        1

0047 01 465  5      000            00000        3      5       1                                                       1

0048 01 017  1  100 030 000    900 00000 00000  2   6  6   3   0  0 00 0 00 0 00 2  3 2  6  0   0   2    2   1    2    1   1

0049 01 503  1  100 030 000        00000 00000  2              0

0050 01 195  1  100 000 000        00000 00000  3              0
```

```
                                                  GENERAL  FOUNDRY  DATA                                           PAGE    3
FDRY CD LOC MET PERCENT CAST  TON/MONTH MELT   SIZ IND WT PRO NOD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST  GI  MI  DI   GI    MI    DI   CLA CLA RG CST     T LB T LB T LB 1 LB 2 LB REP FCE TAP      MOLD      EERP ATK

0051 01 622  1 100 000 000   5500 00000 00000  4   1  4   5   0

0052 01 487  1 100 000 000   6300 00000 00000  4      2       0  0 00 0 00 0 00 0 00 0    1   1   2    1   1    2         1

0053 01 801  1 100 000 000        00000 00000                 0                                                      1

0054 01 624  1 100 000 000        00000 00000  3              0

0055 01 150  1 100 000 000        00000 00000                 0

0056 01 071  1 100 000 000        00000 00000  3              0

0057 01 212  5     000            00000        3   5  5   6   1

0058 01 440  1 100 000 000        00000 00000  4   1  5   5   0                                                           1

0059 01 481  5     000            00000        4   1  3   5   1                                                           1

0060 01 481  5     000            00000        4   1  4   5   1                                                           1

0061 01 441  5  89 000  11   3200 00000    40  4   5  2   5   1            8    0 00 9 00 0   0   1    2   1    2    1    1

0062 01 441  5     000            00000        4   5  4   3   1                                                      1

0063 01 165  2 000 100 000  00000       00000      4          0

0064 01 801  1 100 000 000        00000 00000  3              0                                                      1

0065 01 485  1 100 000 000        00000 00000  4   1      5   0  0 00 0 00 0 00 0 00 0

0066 01 618  4         000              00000  4   1      5   0

0067 01 435  7  65   5  30  47000  4000 21000  4   1  6   5   1                           0   0   1    2   2    2         1

0068 01 486  2 000 100 000  00000 43000 00000  4   1  6   5   0                           1   3   1    2   2    2         1

0069 01 486  1 100 000 000  60000 00000 00000  4   1  4   5   0                           1   1   2    2   2    2         1

0070 01 486  5     000            00000        4   1      5   1                                                           1

0071 01 142  1 100 000 000        00000 00000  4   1  4   5   0                           1   1   2    2   2    2         1

0072 01 480  1 100 000 000  30000 00000 00000  4   1  6   5   0                           1   1   1    3   1    2         1

0073 01 454  1 100 000 000   8000 00000 00000  4   1  3   5   0

0074 01 150  1 100 000 000        00000 00000  3              0

0075 01 146  1 100 000 000        00000 00000                 0
```

```
FDRY CD LOC MET PERCENT CAST  TON/MONTH MELT   SIZ IND WT PRO NOD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST  GI  MI  DI   GI    MI     DI   CLA CLA RG CST     T LB T LB T LB 1 LB 2 LB REP FCE TAP         MOLD      EERP ATK
0076 01 191  1  100 000 000        00000 00000  2               0                                                       1
0077 01 472  1  100 000 000   3300 00000 00000       6  5   3   0
0078 01 131  1  100 000 000        00000 00000  3               0                                                       1
0080 01 917  1  100 000 000        00000 00000                  0                                                       1
0081 01 917  1  100 000 000    400 00000 00000  3    4  4   3   0                                                       1
0082 01 631  1  100 000 000        00000 00000                  0
0083 01 303  1  100 000 000   2350 00000 00000  3               0                                                       1
0084 01 515
0085 01 175
0086 01 917  1  100 000 000        00000 00000                  0                                                       1
0087 01 619  1  100 000 000    500 00000 00000  3    6  6       0 0 00 0 00 0 00 0 00 0      0   0   1    3   1    3         1
0088 01 088  1  100 000 000        00000 00000  4    4  5   3   0                                                       1
0089 01 606  1  100 000 000        00000 00000  2    2      7   0
0090 01 462  1  100 000 000  11200 00000 00000  4    1  6   5   0                1  6 1  9   0   0   2    1   2    1         1
0091 01 402  1  100 000 000  10500 00000 00000  4    2  6   7   0 4  2 5 10      1 10 2 12   0   0   1    2   2    2         1
0092 01 531  2  000 100 000  00000       00000  4    2      7   0
0093 01 601  5   50 000  50   1850 00000  1850  3    3  5   2   1 6 99 4 13 8 30 1 13        0   0   2    2   1    3         1
0094 01 352  5   85 000  15   6800 00000  1200  4    5  4   6   1 4 50 6         1           0   0   2    3   1    3         1
0095 01 534  1  100 000 000        00000 00000  4               0                                                       1
0096 01 488  1  100 000 000    125 00000 00000  2               0                                                       1
0097 01 083  1  100 000 000        00000 00000  2               0
0098 01 482  1  100 000 000        00000 00000  4           1   0                                                       1
0099 01 611  1  100 000 000   5000 00000 00000  4    1  4   1   0 0 00 0 00 0 00 0 00 0 00   1   1   1    2   1              1
0100 01 176  2  000 100 000  00000       00000                  0
0101 01 075  1  100 000 000        00000 00000  4               0                                                       1
```

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                                                GENERAL  FOUNDRY  DATA

FDRY CO LOC MET PERCENT CAST  TON/MONTH MELT    SIZ IND WT PRO NOD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST  GI  MI  DI    GI    MI    DI   CLA CLA RG CST     T LB T LB T LB 1 LB 2 LB REP FCE TAP      MOLD     EERP ATK

0102 01 024  1  100 000 000    500 00000 00000   3       5   2   0
0103 01 631  1  100 000 000        00000 00000   3               0
0104 01 900  5      000            00000         3   6   4   3   1  5              0 00 9 00   1   1   1     1   1    2
0105 01 191  1  100 000 000        00000 00000   3               0
0106 01 331  1  100 000 000        00000 00000   2               0                                                         1
0107 01 496  5   95 000   5    570 00000    30   3               1  9 40                       1   1   1     2   1    3
0108 01 947  5      000            00000         3   6   5   3   1                                                         1
0109 01 850  1      000 000        00000 00000   3               0                                                         1
0110 01 469  2  000 100 000  00000       00000                   0
0111 01 761  1  100 000 000        00000 00000   3               0
0112 01 458  1  100 000 000    630 00000 00000   3   6   5       0                                                         1
0113 01 601  2  000 100 000  00000  2015 00000   4   6   1       0  0 00 0 00 0 00 3    0 00   0   0   1     2   1    1          1
0114 01 481  1  100 000 000        00000 00000   3               0                                                               1
0115 01 374  1  100 000 000        00000 00000   4               0                                                         1
0116 01 532
0117 01 606  2  000 100 000  00000       00000                   0
0118 01 549  5      000            00000         4       5       1                                                         1
0119 01 351  1  100 000 000        00000 00000                   0
0120 01 028  2  000 100 000  00000       00000   3               0                                                               1
0121 01 532  5      000            00000         4               1                                                         1
0122 01 074  1  100 000 000        00000 00000   3   6           0
0123 01 900  1  100 000 000        00000 00000   2               0                                                         1
0124 01                                          2                                                                         1
0125 01 846  5      000            00000         4               1
0126 01 085  5   75 000  25   7500 00000  2500   3   3   5   2   1  6    0 00 0 00 0 00 0 00   0   0   1     2   1    2          1
```

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                                                      GENERAL  FOUNDRY  DATA                                                           PAGE   6
FDRY CO LOC NET PERCENT CAST   TON/MONTH MELT     SIZ IND WT PRO NUD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST  GI  MI  DI   GI     MI    DI     CLA CLA RG CST     T LB T LB T LB 1 LB 2 LB REP FCE TAP      MOLD     EERP ATK
0127 01 900  1  100 000 000        00000 00000  2                0                                                            1
0128 01 452  1  100 000 000   260  00000 00000  3                0                                                            1
0129 01 917  1  100 000 000   350  00000 00000  3   5  5   6     0                                                            1
0130 01 900  1  100 000 000        00000 00000  3                0                                                            1
0131 01 945  1  100 000 000        00000 00000      6  5   3     0                                                            1
0132 01 083  1  100 000 000        00000 00000  2   3      2     0                                                            1
0133 01 631  1  100 000 000   600  00000 00000  3   6  5   6     0                                                            1
0134 01 088  1  100 000 000        00000 00000  4                0
0135 01 535                                     2
0136 01 194  4   11  89 000   500   4000 00000  4   5  1   6     0 0 00 0 00 0 00 0 00 0      0   0   1    3   1    3              1
0137 01 352  4          000              00000  4   5      6     0                                                            1
0138 01 473  1  100 000 000   700  00000 00000  3   4  5   8     0
0139 01 441  5      000            00000        3   6  5   3     1                                                            1
0140 01 112  1  100 000 000   525  00000 00000  3      5         0
0141 01 196  1  100 000 000        00000 00000  4                0                                                            1
0142 01 631  1  100 000 000   350  00000 00000      6  5   3     0
0143 01 761  1  100 000 000        00000 00000  3                0
0144 01 195  1  100 000 000   400  00000 00000  3   6  4   8     0
0145 01 331  1  100 000 000        00000 00000  2                0                                                            1
0146 01 080  5   60 000  40 16000  00000 12800  4   3  5   2     1 6    4                     1   1   1    3   1    3              1
0147 01 352  5      000            00000        4   4  5   3     1
0148 01 374  1  100 000 000        00000 00000  4                0
0149 01 374  1  100 000 000        00000 00000  4                0
0150 01 945  5   79 000  22  4500  00000  1250  3   3  5   2     1 6 45 4 40      1 4 1 3   1   1   2    1   1    2              1
0151 01 604  1  100 000 000        00000 00000  3                0
```

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                                                 GENERAL  FOUNDRY  DATA

FDRY CD LOC NET PERCENT CAST  TON/MONTH MELT   SIZ IND WT PRO NOD ALLOY ADDITIONS TO LADLE CUP TYP VENT EFF VENT EFF VISITED BY
 NO. TY     CST  GI  MI  DI   GI        MI      DI CLA CLA RG CST    T LB T LB T LB 1 LB 2 LB REP FCE TAP      MOLD          EERP ATK

0152 01 156  1  100 000 000         00000 00000 4              0

0153 01 625  4          000               00000 4              0

0154 01 614  1  100 000 000         00000 00000 3              0

0155 01 982  1  100 000 000         00000 00000 2              0                                                        1

0156 01 463  1  100 000 000         00000 00000 3              0

0157 01 950  1  100 000 000     200 00000 00000 3              0                                                        1

0158 01 757  1  100 000 000    7300 00000 00000 4              0                                                        1

0159 01 494  1  100 000 000     375 00000 00000 3   4  3       0

0160 01 374  1  100 000 000   24000 00000 00000 4   1  6   1   0  0 00 0 00 0 00 0 00 0    0    0   2    3    1    3         1

0161 01 191  1  100 000 000         00000 00000                0

0162 01 070  1  100 000 000         00000 00000 3              0

0163 01 070  1  100 000 000         00000 00000 4              0

0165 01 523  5   85 000  15     850 00000   150 3   5  6   6   1  4  9                9 00 0    0   2    1    2    1         1

0166 01 071

0167 01 081  1  100 000 000    3000 00000 00000                0  0 00 0 00 0 00 0 00 0 00

0168 01 625  1  100 000 000     435 00000 00000 2   6  5       0                           1        1         1    3         1
```

APPENDIX B
EXHIBIT I
SECTION 2 PAGE 1

```
                                                        FURNACE  DATA

            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT HT PR DT ******BLAST**** SIZE HT CHG  AFT AFT DIS POWR CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY SYS

0001 10   1   1   1   3   1   1   2   2       1  0  0   1  66 000  15           8600              52                     0000   1
0001 10   2   1   1   3   1   1   2   2       1  0  0   1  78 000  15           8600              52                     0000   1
0001 10   3   1   1   3   1   1   2           1  0  0   1  48 000   8           4500              43                     0000   1
0001 10   4   1   1   3   1       2           1  0  0   1  48 000   8           4500              43                     0000
0002 10   1   1   1   3   1   1   2   1       2  0  0   1  54 000   9           6000              45                     0000   1
0002 10   2   1   1   3   1   1   2   1       2  0  0   1  54 000   9           6000              45                     0000   1
0003 10   1   1   1                                     1     000   7                                                    0000   1
0004 10   1   2       0   0   0   1   0   0   0  0  0   2 000 100  00 00 24 00 00000   00 0000    00 00   0 0000   0 000 1400   0
0004 10   2   3   1   0   0   0   1   0   0   0  0  0   1 000  18   6 24 24 00 00000   00 0000    00 00   0 0000   0 000 3600   0
0004 10   3   4   1   0   0   0   1   3   0   0  0  0   1 120  20  13 24 24 00 00000   00 0000    00 00   0 0000   0 000 1400   1
0004 10   4   4   1   0   0   0   1   3   0   0  0  0   1 120 100  13 24 24 00 00000   00 0000    00 00   0 0000   0 000 1400   1
0004 10   5   4   1   0   0   0   1   3   0   0  0  0   1 120 100  13 24 24 00 00000   00 0000    00 00   0 0000   0 000 1400   1
0005 10   1   1   1   3   1   1   2   1   2   1  0  0   1  42 000   7           3500              76                     0000   1
0006 10   1   1   1                                     1     000   9                                                    0000   1
0007 10   1   1   1   3   1   1   2   2   2   1  0  0   1  72 000  20  8    00  5500   20         51 35   0 3700   3  40 0000   1
0008 10   1   1   2   3   1   1   2   1   1   1  0  0   1  60 000  11  8  8 00  5000   14         23 19   0 3300   1 252 0000   1
0009 10   1   1   1   2   3   1   2   1   2   1  0  0   1  66 000  18          10500        750    52        4000         0000   1
0009 10   2   1   1   2   3   1   2   1   2   1  0  0   1  66 000  18          10500        750    52        4000         0000   1
0009 10   3   1   1   3   1   1   2   1   2   1  0  0   1  56 000  11 14    00  4550              52        4000         0000   2
0010 10   1   1   1                                     1     000   9                                                    0000   1
0011 10   1   1   1   3   1   1   2   1   2   1  0  0   1  84 000  10           5200              54                     0000   1
0012 10   1   1   1   1   3   2   2   8   0   1  0  0   1 114 000  45 18 00 00 19000       1100    84 27   0 0000   0 000 0000   1
0012 10   2   1   2   1   3   2   2   8   0   1  0  0   1 114 000  35 24 00 00 26000        800    84 27   0 0000   0 000 0000   1
0012 10   3   1   1   2   3   2   2   8   0   1  0  1   1  48 000  14 18 00 00  8500        450    54 26   0 0000   0 000 0000   0
0012 10   4   1   2   3   1   2   2   8   0   1  0  0   1  48 000   6  6 00 00  6000              54 26   0 0000   0 000 0000   0
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            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT HT PR OT ******BLAST**** SIZE  HT CHG  AFT AFT DIS POWR CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH.DR DR PRE SIZE LOC AFT SPLY SYS

0012 10   5   1   1   2   3   2   2   8   0   1  0  0   1  30 000   3  8 00 00  3500       400    18 18   0 0000   0 000 0000   0

0013 10   1   1   1   3   1   1   2   1   0   1  0  0   1  72 000  18  2        5000              30        0000   0 000 0000   1

0013 10   2   1   1                           1  0  0   1     000  10  2                                                 0000

0014 10   1   1   1   3   1   1   2                     1  54 000  10                                                    0000   1

0014 10   2   1   1   3   1   1   2                     1  54 000  10                                                    0000   1

0015 10   1   1   1   3   1   1   2   1   1   2  0  0   1  42 000   6           3600              10                     0000   1

0016 10   1   1   1           2       8       1  0  0   1  52 000  11           5000              44                     0000   1

0016 10   2   1   1           2       8       1  0  0   1  52 000  11           5000              44                     0000   2

0017 10   1   1   1           1   2                     1  37 000               2400                                     0000   1

0017 10   2   1   1           1   2                     1     000                                                        0000   1

0018 10   1   1   2   3   1   2   2   8       1  0  0   1  48 000   8           4500      0000    11                     0000   1

0018 10   2   1   2   3   1   2   2   8       1  0  0   1  48 000   8           4500      0000    11                     0000   2

0019 10   1   1   1   3   1   2   2   8   0   1  0  0   1  48 000  18                             28        0000   0 000 0000   1

0019 10   2   1   1   3   1   2   2   8   0   1  0  0   1  48 000  18                             28        0000   0 000 0000   2

0019 10   3   6   0   0   0   0   0   0   0   0  0  0   3 000  30  00 00       00000   00 0000    00 00   0 0000   0 000 0000

0019 10   4   6   0   0   0   0   0   0   0   0  0  0   3 000  30  00 00       00000   00 0000    00 00   0 0000   0 000 0000

0020 10   1   2   6   0   0   0   0   0   0   0  0  0   1 000  13  .5          00000   00 0000    00 00   0 0000   0 000

0020 10   2   2   6   0   0   0   0   0   0   0  0  0   1 000  13  .5          00000   00 0000    00 00   0 0000   0 000 0000

0021 10   1   1   4   2   3   1   2   1   0   1  0  1   1  68 000  18 22 22 00  9000   36 1000    80 38   0 0000   0 000 0000   1

0021 10   2   1   4   1   3   1   2   1   0   1  0  1   1  68 000  18 22 22 00  9000   36 1000    80 38   0 0000   0 000 0000   1

0022 10   1   3   1   0   5   0   0   0   0   0  0  0   1 000   9   5          00000   00 0000    00 00   3 0000   0 000 1750

0022 10   2   3   1   0   5   0   0   0   0   0  0  0   1 000   9   5          00000   00 0000    00 00   3 0000   0 000 1750

0022 10   3   3   1   0   5   0   0   0   0   0  0  0   1 000   9   5          00000   00 0000    00 00   3 0000   0 000 1750

0022 10   4   3   1   0   5   0   0   0   0   0     0   1 000   9   5          00000   00 0000    00 00   3 0000   0 000 1750

0023 10   1   1   1   3   1   1   2   1                 1  76 000               6000                                     0000   1
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                                                    FURNACE  DATA

                      **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST**** SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0024 10   1   1   4   2   3   1   2   1       1  0  0   1  86 000 32           22000       750                           0000    1
0024 10   2   1   4   2   3   1   2   1       1  0  0   1  86 000 32           22000       750                           0000    1
0025 10   1   1   4   3   1   2   2   8   2   1  0  1   1  84 000 20  13       11000           70         1        4     0000    1
0026 10   1   1   1   3   1   1   2   1   2   1  0  0   1  54 000 10  10    00  5400   19      58         0 8000   2 720 0000    1
0026 10   2   1   1   3   1   1   2   1   2   1  0  0   1  54 000 10  10    00  5400   19      58         0 8000   2 720 0000    1
0027 10   1   1   1   3   1   2   2   8   0   1  1  0   1  72 000 14   8        8000   14      68    33   0 0000   0 000 0000    1
0028 10   1   1   1                                     1     000  4                                                     0000
0028 10   2   3   1   0   5   0   0   0   0   0  0  0   1 000     .8           00000   00 0000 00    00     0000   0 000
0029 10   1   1   4   2   3   1   2   1   6   1  0  0   1  78 000 15  14       12000   20  750 50         0 1780   1 276 0000    1
0029 10   2   4   1   0   0   0   2   8   0   0  0  0   3  72   6 00     16    00000   00 0000 00    00   0 0000   0 000 1000    0
0029 10   3   4   1   0   0   0   2   8   0   0  0  0   3  72   6 00     16    00000   00 0000 00    00   0 0000   0 000 1000    0
0029 10   4   4   1   0   0   0   2   8   0   0  0  0   3  60   6 00     16    00000   00 0000 00    00   0 0000   0 000 1000    0
0030 10   1   4   1   0   0   0           0   0  0  0   1      .5              00000   00 0000 00    00     0000   0 000
0030 10   2   4   1   0   0   0           0   0  0  0   1       2              00000   00 0000 00    00     0000   0 000
0030 10   3   4   1   0   0   0           0   0  0  0   1       4              00000   00 0000 00    00     0000   0 000
0031 10   1   1   4   2   3   1   2   1   0   1  0  0   1  96 000 35           15000       750 60         0 0000   0 000 0000    1
0031 10   2   1   4   2   3   1   2   1   0   1  0  0   1  96 000 35           15000       750 60         0 0000   0 000 0000    1
0032 10   1   1   1   3   1   2   2   8   2   1  1  0   1  56 000 16   7        5400   15      60    26   0 1000   2  31 0000    1
0032 10   2   6   0   0   0   0   0   0   0   0  0  0   3      20 00  00 10  5 00000   00 0000 00    00   0 0000   0 000 0000    0
0033 10   1   1   4   1   3   1   2   1   2   1  0  0   1 108 000 50           25000      1400 99                        0000    1
0033 10   2   1   4   1   3   1   2   1   2   1  0  0   1 108 000 50           25000      1400 99                        0000    2
0033 10   3   2   7   0   0   0   0   0   0   0  0  0   1 000 137 10           00000   00 0000 00    00   0 0000   0 000 4400
0033 10   4   2   7   0   0   0   0   0   0   0  0  0   1 000 137 10           00000   00 0000 00    00   0 0000   0 000 4400
0033 10   5   2   7   0   0   0   0   0   0   0  0  0   1 000 137 10           00000   00 0000 00    00   0 0000   0 000 4400
0033 10   6   2   7   0   0   0   0   0   0   0  0  0   2 000 137 00  00       00000   00 0000 00    00   0 0000   0 000 2200
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               **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT HT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR  CTL
NO.  TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0033 10   7  2   7   0   0   0   0   0   0   0  0  0   2 000 137 00  00       00000 00  0000 00   00  0 0000   0 000 2200
0034 10   1  1   4   1   3   1   2   2   0   1  0  0   1 108 000 50           25000     1000 99          0000   0 000 0000   1
0034 10   2  2   6   0   5   0   0   0   0   0  0  0   5 000 100 10  00       00000 00  0000 00   00    0000   0 000 4000
0035 10   1  1   4   2   3   1   2   1   2   1  0  0   1  54 000 13   9  9 00  5500 25   600 55       0                0000   1
0035 10   2  1   2   3   1   2   2   8   0   1  0  0   1  48 000  8   9  9 00  4500          55       0 0000   0 000 0000   2
0035 10   3  1   2   3   1   2   2   8   0   1  0  0   1  48 000  8   9  9 00  4500          55       0 0000   0 000 0000   3
0035 10   4  2   7   0   0   0   0   0   0   0  0  0   3 000  14 00  00  9 00 00000 00  0000 00   00  0 0000   0 000  420
0036 10   1  1   1   3   1   1   2   1   2   1  0  0   1  42 000  4           2500           5                         0000   1
0037 10   1  1   1   3   1   1   2   1   2   1  0  0   1  34 000  4   2       2000           4                         0000   1
0038 10   1  1   4   1   3   1   2   1   0   1  0  0   1  78 000 23                     1000 95          0000   0 000 0000   1
0040 10   1  1                                         1     000  6                                                  0000
0040 10   2  1                                         1     000  6                                                  0000
0040 10   3  1                                         1     000  6                                                  0000
0040 10   4  4       0       0           0   0  0  0                          00000 00  0000 00   00    0000   0 000
0041 10   1  1               1   2                     1     000  4                                                  0000   1
0041 10   2  2       0       0   0   0   0   0  0  0     000 .75              00000 00  0000 00   00    0000   0 000
0041 10   3  2       0       0   0   0   0   0  0  0     000 .25              00000 00  0000 00   00    0000   0 000
0041 10   4  2       0       0   0   0   0   0  0  0     000 .20              00000 00  0000 00   00    0000   0 000
0042 10   1  1   4   1   3   2   2   8   2   1  0  0   1  72 000 25  16       12000 64  1000 16   46  0 2100   1 480 0000   1
0042 10   2  2   5   0   0   0   0   0   0   0  0  0   2 000   9 00  00    24 00000 00  0000 00   00  0 0000   0 000  600   0
0042 10   3  2   5   0   0   0   0   0   0   0  0  0   2 000   9 00  00    24 00000 00  0000 00   00  0 0000   0 000  600   0
0043 10   1  1   1   3   1   2   2   1   2   1  0  1   1  54 000 11   5       5300          50       0 4500   2       0000   1
0044 10   1  1   4   1   3   2   2   8       1  0  0   1  72 000 20                     1400                             0000
0044 10   2  1   4   1   3   2   2   8       1  0  0   1  72 000 20                     1400                             0000
0044 10   3  2   6   0       0   0   0   0   0  0  0   3 000  30 00  00       00000 00  0000 00   00  0 0000   0 000  750
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                                                                     FURNACE  DATA                                         PAGE    5

             **********FURNACE CLASSIFICATION*********
FDRY CO FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST**** SIZE  HT CHG  AFT AFT DIS PDWR CTL
NO.  TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY SYS

0044 10   4   2   6   0       0   0   0   0   0  0  0   3 000  30  00 00       00000   00 0000 00    00   0 0000   0 000  750

0045 10   1   1   4   1   3   2   2   8   0   1  0  0   1  84 000  18          10000      1400 88           0000   0 000 0000

0045 10   2   1   4   1   3   2   2   8   0   1  0  0   1  84 000  18          10000      1400 88           0000   0 000 0000

0045 10   3   1   4   1   3   2   2   8   0   1  0  0   1  84 000  18           9500      1400 72           0000   0 000 0000

0045 10   4   1   4   1   3   2   2   8   0   1  0  0   1  84 000  18           9500      1400 72           0000   0 000 0000

0045 10   5   1   4   1   3   2   2   8   0   1  0  0   1  84 000  18           9500      1400 84           0000   0 000 0000

0045 10   6   1   4   1   3   2   2   8   0   1  0  0   1  84 000  18           9500      1400 84           0000   0 000 0000

0045 10   7   1   4   1   3   1   2   1   0   1  0  0   1  96 000  26          12000      1400 70           0000   0 000 0000   1

0045 10   8   1   4   1   3   1   2   1   0   1  0  0   1  96 000  26          12000      1400 70           0000   0 000 0000   1

0046 10   1   4   1   0   0   0   1   3   0   0  0  0   1 103  15  13 16       00000   00 0000 00    00   0 0000   0 000 9100   1

0046 10   2   4   1   0   0   0   1   3   0   0  0  0   1 103  15  13 16       00000   00 0000 00    00   0 0000   0 000 9100   1

0046 10   3   4   1   0   0   0   1   3   0   0  0  0   1 103  15  13 16       00000   00 0000 00    00   0 0000   0 000 9100   2

0046 10   4   4   1   0   0   0   1   3   0   0  0  0   1 103  15  13 16       00000   00 0000 00    00   0 0000   0 000 9100   2

0046 10   5   2   6   0   0   0   0   0   0   0  0  0   2 000  83  00 00 15    00000   00 0000 00    00   0 0000   0 000 1400   0

0046 10   6   2   6   0   0   0   0   0   0   0  0  0   2 000  83  00 00 15    00000   00 0000 00    00   0 0000   0 000 1400   0

0046 10   7   2   6   0   0   0   0   0   0   0  0  0   2 000  83  00 00       00000   00 0000 00    00   0 0000   0 000        0

0047 10   1   1   1   2   3   1   2   1   2   1  0  0   1  54 000  10           7000       500 35                        0000   1

0047 10   2   1   1   2   3   1   2   1   2   1  0  0   1  54 000  10           7000       500 35                        0000   1

0048 10   1   4   1   0   0   0   1   4   0   0  0  0   1 103  20   8  8    00 00000   00 0000 00    00   0 0000   0 000 6000   1

0048 10   2   2   7   0   0   0   0   0   0   0  0  0   2 000  22  00 00  2 22 00000   00 0000 00    00   0 0000   0 000  800

0048 10   3   2   7   0   0   0   0   0   0   0  0  0   2 000  22  00 00  2 22 00000   00 0000 00    00   0 0000   0 000  800

0048 10   4   2   7   0   0   0   0   0   0   0  0  0   2 000  22  00 00  2 22 00000   00 0000 00    00   0 0000   0 000  800

0049 10   1   1               1   2   1       2         1  72 000   5           3500                                     0000   1

0050 10   1   1   1   3   1   1   2   1       1  0  0   1  66 000  17           6000                                     0000   1

0051 10   1   1   1   3   1   1   2   1   0   1  0  0   1  48 000  10           6000            55           0000   0 000 0000   1
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                                                          FURNACE  DATA                                       PAGE    6

            **********FURNACE CLASSIFICATION**********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST**** SIZE  HT CHG  AFT AFT DIS POWR CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY SYS

0051 10   2   1   1   3   1   1   2   1   0   1  0  0   1  48 000  10           6000           55           0000   0 000 0000   1
0052 10   1   1   1   2   3   2   2   8   0   1  0  1   1  60 000  16 16        5900   18  450 60         0 0000   0 000 0000   0
0052 10   2   1   1   2   3   2   2   8   0   1  0  1   1  60 000  16 16        5900   18  450 60         0 0000   0 000 0000   1
0052 10   3   1   1   2   3   2   2   8   0   1  0  1   1  60 000  16 16        5900   18  450 60         0 0000   0 000 0000   0
0052 10   4   1   1   3   1   2   2   8   4   1  0  0   1  48 000   8  8        3500   16      60         0 1000   4 480 0000   2
0053 10   1   4       0   0   0           0   0  0  0                          00000   00 0000 00    00     0000   0 000
0054 10   1   1   1   3   1   1   2   1   0   1  0  0   1  60 000  15           8800                        0000   0 000 0000   1
0055 10   1   1                                         1     000   2                                                    0000
0055 10   2   1                                         1     000   5                                                    0000
0056 10   1   1               1   2                     1  54 000   9                                                    0000   1
0057 10   1   1   1   3   1                             1     000   8                                                    0000   1
0058 10   1   1   4   1   3   1   2   1   2   1  0  0   1  96 000  30                     1000                           0000   1
0058 10   2   1   4   1   3   1   2   1   2   1  0  0   1  96 000  30                     1000                           0000   2
0058 10   3   1   4   1   3   1   2   1   2   1  0  0   1  96 000  35                     1000                           0000   3
0058 10   4   1   4   1   3   1   2   1   2   1  0  0   1  96 000  35                     1000                           0000   4
0058 10   5   1   4   1   3   1   2   1   2   1  0  0   1  96 000  35                     1000                           0000   5
0058 10   6   1   4   1   3   1   2   1   2   1  0  0   1  96 000  35                     1000                           0000   6
0058 10   7   1                                         1  96 000  35                                                    0000
0058 10   8   4   1   0   0   0           0   0  0  0            12              00000   00 0000 00    00     0000   0 000
0059 10   1   1   4   1   3   1   2   1       1         1  96 000  25                     1000                           0000   1
0059 10   2   1   4   1   3   1   2   1       1         1  96 000  25                     1000                           0000   2
0059 10   3   1   4   1   3   1   2   1       1         1  96 000  25                     1000                           0000   3
0059 10   4   1   4   1   3   1   2   1       1         1  96 000  25                     1000                           0000   4
0059 10   5   1   4   1   3   1   2   1       1         1  96 000  35                     1000                           0000   5
0059 10   6   1   4   1   3   1   2   1       1         1  96 000  35                     1000                           0000   6
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                                                         FURNACE  DATA                                                    PAGE   7

            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT HT PR DT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0059 10   7   1   4   1   3   1   2   1       1         1  96 000  35                     1000                           0000    7
005  10   8   1   4   1   3   1   2   1       1         1  96 000  35                     1000                           0000    8
0059 10   9   1   4   1   3   1   2   1       1         1  96 000  35                     1000                           0000    9
0059 10  10   4   1   0   0   0       3   0   0  0  0   2 120  20  00 00       00000   00 0000 00     00   0 0000   0 000
0059 10  11   2   6   0   0   0   0   0   0   0  0  0   2 000  14  00 00       00000   00 0000 00     00   0 0000   0 000
0059 10  12   2   6   0   0   0   0   0   0   0  0  0   2 000  14  00 00       00000   00 0000 00     00   0 0000   0 000
0060 10   1   1   4   1   3   1   2   1       1         1  84 000  15                     1000 99                        0000
0060 10   2   1   4   1   3   1   2   1       1         1  84 000  15                     1000 99                        0000
0060 10   3   1   4   1   3   1   2   1       1         1  90 000  22                     1000 99                        0000
0060 10   4   1   4   1   3   1   2   1       1         1  90 000  22                     1000 99                        0000
0060 10   5   1   4   1               1       1         1  90 000  22                     1000                           0000
0060 10   6   1   4   1               1       1         1  90 000  22                     1000                           0000
0060 10   7   4   2   0   0   0           0   0  0  0   2       1  00 00       00000   00 0000 00     00   0 0000   0 000
0060 10   8   4   2   0   0   0           0   0  0  0   2       1  00 00       00000   00 0000 00     00   0 0000   0 000
0060 10   9   4   2   0   0   0           0   0  0  0   2       1  00 00       00000   00 0000 00     00   0 0000   0 000
0060 10  10   4   2   0   0   0           0   0  0  0   2       4  00 00       00000   00 0000 00     00   0 0000   0 000
0060 10  11   4   2   0   0   0           0   0  0  0   2       4  00 00       00000   00 0000 00     00   0 0000   0 000
0060 10  12           0       0   0   0   0   0  0  0     000   4              00000   00 0000 00     00     0000   0 000
0061 10   1   1   1   1   3   1   2   1   2   1  0  0   1  65 000  20  8  8 00 10000   24 1000 61         0 1500   1 480 0000    1
0061 10   2   2       0   0   0   0   0   0   0  0  0   1 000 1.5   1  8  8 00 00000   00 0000 00     00   0 0000   0 000         0
0062 10   1   1   1   1   3   1   2   1   2   1  0  0   1  66 000  14            8000      1000 48                        0000    1
0062 10   2   1   1   1   3   1   2   1   2   1  0  0   1  66 000  14            8000      1000 48                        0000    1
0063 10   1   4   1   0   0   0   1   3   0   0  0  0   1 132      12          00000   00 0000 00     00     0000   0 000 5000    1
0063 10   2   4   1   0   0   0   1   3   0   0  0  0   1 108       4          00000   00 0000 00     00     0000   0 000 3500    1
0064 10   1   1   1                                     1     000   8                                                    0000
```

FURNACE DATA

			**********FURNACE CLASSIFICATION*********																		******BLAST****										
FDRY NO.	CD TY	FCE NO	FCE TYP	LIV TYP	BLT DES	BLT HTG	TOP C/O	CHG	GAS T-O	AFT	CHG DR	FL IN	OX EN	FCE USE	FCE DIA	HLD CAP	MLT RAT	MT UT	PR UT	OT UT	VOLUM	PRES	TEMP	SIZE CH DR	HT DR	CHG PRE	AFT SIZE	AFT LOC	DIS AFT	POWR SPLY	CTL SYS
0064	10	2	1	1										1		000	21													0000	
0065	10	1	1	4	1	3	1	2	1	2	1	0	0	1	84	000	35				16000		1600	96		0	1500	1	600	0000	1
0065	10	2	1	4	1	3	1	2	1	2	1	0	0	1	84	000	35				16000		1600	96		0	1500	1	600	0000	2
0065	10	3	1	4	1	3	1	2	1	2	1	0	0	1	102	000	40				16000		1000							0000	3
0065	10	4	1	1	2	3	2	2	8		1	0	0	1	108	000	25				16000		750							0000	4
0065	10	5	1	1	2	3	2	2	8		1	0	0	1	108	000	25				16000		750							0000	5
0065	10	6	1	1	2	3	2	2	8		1	0	0	1	108	000	25				16000		750							0000	6
0065	10	7	4		0	0	0			0	0	0	0			10					00000	00	0000	00	00		0000	0	000		
0066	10	1	1	1										1		000	35													0000	
0066	10	2	1	1										1		000	35													0000	
0066	10	3	1	1										1		000	35													0000	
0066	10	4	1	4	1	3	2	2	8	0	1	0	0	1	108	000	35				25000		1000				0000	0	000	0000	
0066	10	5	1	4	1	3	1	2	2	0	1	0	0	1	108	000	40				25000	30	1000	97			0000	0	000	0000	1
0066	10	7	4	1	0	0	0	1		0	0	0	0	2	96	15	00	00			00000	00	0000	00	00	0	0000	0	000		
0066	10	8	2	6	0	0	0	0	0	0	0	0	0	2	000		00	00			00000	00	0000	00	00	0	0000	0	000		
0067	10	1	1	4	1	3	1	2	1	1	1	0	0	1	114	000	45	16		00	25000	72	1200	99	46	0	6000	2		0000	1
0067	10	2	1	4	1	3	1	2	1	1	1	0	0	1	114	000	50	16		00	25000	72	1400	51	35	0	9999	1		0000	2
0067	10	3	1	4	1	3	2	2	8	0	1	0	0	1	102	000	45	8		00	25000	72	1200	57	37	0	0000	0	000	0000	3
0067	10	4	3	3	0	5	0	1	0	0	0	0	0	1		33	10	10	2	4	00000	00	0000	00	00	2	0000	0	000	1300	0
0067	10	5	2	7	0	5	0	1	0	0	0	0	0	2		60	00	00	16	00	00000	00	0000	00	00	0	0000	0	000	1100	0
0067	10	6	2	7	0	5	0	1	0	0	0	0	0	2		60	00	00	16	00	00000	00	0000	00	00	0	0000	0	000	1100	0
0067	10	7	4	3	0	0	0	1	0	0	0	0	0	2		30	00	00	8	00	00000	00	0000	00	00	0	0000	0	000	3500	0
0067	10	8	4	3	0	0	0	1	0	0	0	0	0	2		4	00	00	8	00	00000	00	0000	00	00	0	0000	0	000	3500	0
0068	10	1	1	1	2	3	2	2	8	0	1	0	0	1	102	000	45	16	00	00	20000	35	350	85	30	0	0000	0	000	0000	1
0068	10	2	1	1	2	3	2	2	8	0	1	0	0	1	102	000	45	16	00	00	20000	35	350	85	30	0	100	1		0000	2

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                                                     FURNACE  DATA                                                   PAGE    9

                 **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST**** SIZE  HT CHG  AFT AFT DIS PDWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0068 10   3   1   1   2   3   2   2   8   0   1  0  0   1 102 000  45 16 00 00 20000   35  350    85 30   0  100   1     0000    3

0068 10   4   1   1   2   3   2   2   8   0   1  0  0   1 102 000  45    00 00 20000   35  350    85 30   0  100   1     0000    4

0068 10   5   3       0   0   0   0   0   1   0  0  0   1  72  65  40 16 16 00 00000   00 0000    00 00   1 5000                  5

0068 10   6   3       0   0   0   0   0   1   0  0  0   3  60  33  10    16    00000   00 C000    00 00   0 0000         1700

0068 10   7   4   1   0   0   0   0   0   1   0  0  0   3 108  18   3    16    00000   00 0000    00 00   0 0000          470

0068 10   8   4   1   0   0   0   0   0   1   0  0  0   3 108  18   3    16    00000   00 0000    00 00   0 0000          350

0068 10   9   4   1   0   0   0   0   0   1   0  0  0   3 108  18   3    16    00000   00 0000    00 00   0 0000          350

0069 10   1   1   1   1   3   1   2   2   0   1  0  1   1 114 000  55 16       28000   80 1000       51   0 0000   0 000 0000    5

0069 10   2   1   1   1   3   1   2   2   0   1  0  1   1 114 000  55 16       28000   80 1000       51   0 0000   0 000 0000    6

0069 10   3   1   1   1   3   1   2   2   0   1  0  1   1 108 000  45 16       20000   56 1000       58   0 0000   0 000 0000    3

0069 10   4   1   1   1   2   1   2   2   0   1  0  1   1 108 000  45 16       22000   72 1000       58   0 0000   0 000 0000    4

0069 10   5   1   1   1   2   1   2   2   0   1  0  1   1 102 000  35 16       20000   56 1000       46   0 0000   0 000 0000    1

0069 10   6   1   1   1   2   2   2   2   0   1  0  1   1 102 000  35 16       20000   56 1000       46   0 0000   0 000 0000    2

0069 10   7   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10   8   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10   9   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  10   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  11   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  12   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  13   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  14   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  15   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  16   1   1   3   1   2   2   8   0   1  0  0   1  72 000  20 16       15000   40            25   0 0000   0 000 0000

0069 10  17   4   1   0   0   0   0   0   0   0  0  0   3  96  17  00 00 15    00000   00 0000    00 00   0 0000   0 000 3500

0069 10  18   4   1   0   0   0   0   0   0   0  0  0   1 108  18   3  8 16 00 00000   00 0000    00 00   0 0000   0 000 6250
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            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT HT PR DT ******BLAST****  SIZE  HT CHG  AFT  AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR  IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP  CH DR DR PRE  SIZE LOC AFT SPLY  SYS

0069 10  19  4   1   0   0   0   0   0   0   0  0  0   1   60   3  1   8 00 00 00000 00   0000  00    00  0   0000  0  000 1100
0069 10  20  2   7   0   0   0   0   0   0   0  0  0   3   72  33 00  00 16 00 00000 00   0000  00    00  0   0000  0  000 1100
0069 10  21  2   7   0   0   0   0   0   0   0  0  0   3   72  33 00  01 60 00 00000 00   0000  00    00  0   0000  0  000 1100
0069 10  22  4   1   0   0   0   0   0   0   0  0  0   3   67   6 00  00 16 00 00000 00   0000  00    00  0   0000  0  000 1600
0070 10   1  1   4   1   3   1   2   2   0   1  0  0   1  102 000 50           22500      1000                0000  0  000 0000   1
0070 10   2  1   4   1   3   1   2   2   0   1  0  0   1  102 000 50           22500      1000                0000  0  000 0000   2
0070 10   3  1   4   1   3   1   2   2   0   1  0  0   1  102 000 50           22500      1000                0000  0  000 0000   3
0070 10   4  1   4   1   3   1   2   2   0   1  0  0   1  102 000 50           22500      1000                0000  0  000 0000   4
0070 10   5  1   4   1   2   1   2   2   0   1  0  0   1  102 000 50           22500      1000                0000  0  000 0000
0070 10   6  4   2   0   0   0           0   0  0  0   3        40              00000 00   0000  00    00      0000  0  000
0070 10   7  4   2   0   0   0           0   0  0  0   3        40              00000 00   0000  00    00      0000  0  000
0070 10   8  2   6   0   0   0   0   0   0   0  0  0   3  000  40              00000 00   0000  00    00      0000  0  000
0071 10   1  1   4   1   3   1   2   2   0   1  0  1   1   96 000 40  16 16    17500 80   1100        51  0   0000  0  000 0000   1
0071 10   2  1   4   1   3   1   2   2   0   1  0  1   1   96 000 40  16 16    17500 80   1100        51  0   0000  0  000 0000   2
0071 10   3  1   4   1   3   1   2   2   0   1  0  1   1   96 000 40  16 16    17500 80   1100        51  0   0000  0  000 0000   3
0071 10   4  1   4   1   3   1   2   2   0   1  0  1   1  108 000 50  16 16    17500 96   1100        57  0   0000  0  000 0000
0071 10   5  2   7   0   0   0   0   0   0   0  0  0   2  000  26 00  00 16 24 00000 00   0000  00    00  0   0000  0  000        0
0071 10   6  2   7   0   0   0   0   0   0   0  0  0   2  000  26 00  00 16 24 00000 00   0000  00    00  0   0000  0  000        0
0071 10   7  2   7   0   0   0   0   0   0   0  0  0   2  000  26 00  00 16 24 00000 00   0000  00    00  0   0000  0  000        0
0071 10   8  2   7   0   0   0   0   0   0   0  0  0   2  000  26 00  00 16 24 00000 00   0000  00    00  0   0000  0  000        0
0071 10   9  2   7   0   0   0   0   0   0   0  0  0   2  000  26 00  00 16 24 00000 00   0000  00    00  0   0000  0  000        0
0071 10  10  2   7   0   0   0   0   0   0   0  0  0   2  000  54 00  00 16 24 00000 00   0000  00    00  0   0000  0  000        0
0072 10   1  1   4   2   3   2   2   8   0   1  0  0   1   96 000 30  16 16 00 15000 30    700  88    30  4   0000  0  000 0000   1
0072 10   2  1   4   2   3   2   2   8   0   1  0  0   1   96 000 30  16 16 00 15000 30    700  88    30  4   0000  0  000 0000   2
0072 10   3  1   4   1   3   2   2   8   0   1  0  0   1   96 000 30  16 16 00 15000 30    900  88    39  4   0000  0  000 0000   3
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            **********FURNACE CLASSIFICATION**********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR   CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY   SYS

0072 10   4  1   4   1   3   2   2   8   0   1   0  0  1   96 000  30 16 16 00 15000   30  900 88    39  4  0000  0  000 0000    4
0072 10   5  1   4   3   1   2   2   8   0   1   0  0  1   92 000  24 16 16 00 12000   30      88    30  4  0000  0  000 0000    5
0072 10   6  1   4   3   1   2   2   8   0   1   0  0      84 000  21 16 16 00 12000   30      88    30  4  0000  0  000 0000    6
0072 10   7  4   1   0   0   0   0   0   0   0   0  0  3  105  15  00 00 16    00000   00 0000 00    00  0  0000  0  000 3500
0072 10   8  4   1   0   0   0   0   0   0   0   0  0  3  105  15  00 00 16    00000   00 0000 00    00  0  0000  0  000 3500
0072 10   9  4   1   0   0   0   0   0   0   0   0  0  3  105  15  00 00 16    00000   00 0000 00    00  0  0000  0  000 6500
0072 10  10  4   1   0   0   0   1   3   0   0   0  0  1  178  65  00 18 16    00000   00 0000 00    00  4  0000  0  000 2000    7
0073 10   1  1   4   1   3   1   2   1   2   1   0  0  1  102 000  45          18000      1200              3000         0000    1
0073 10   2  1   4   1   3   1   2   1   2   1   0  0  1  102 000  45          18000      1200              3000         0000    1
0074 10   1  1   1           2   2   8       1         1   48 000  10           4000           15                        0000    1
0075 10   1  4   1   0   0   0   1   3   0   0   0  0  1  108   8   4          00000   00 0000 00    00     0000  0  000 5000    1
0076 10   1  1                               2         1   36 000   3           5600           33                        0000    1
0076 10   2          0       0   0   0   0   0   0  0     000       1          00000   00 0000 00    00     0000  0  000
0076 10   3          0       0   0   0   0   0   0  0     000       1          00000   00 0000 00    00     0000  0  000
0076 10   4          0       0   0   0   0   0   0  0     000       1          00000   00 0000 00    00     0000  0  000
0077 10   1  1   1   1   3   1   2   1   2   1   0  0  1   48 000  10                     1000                           0000    1
0077 10   2  1   1   1   3   1   2   1   2   1   0  0  1   48 000  10                     1000                           0000    1
0077 10   3  1   1   1   3   1   2   1   2   1   0  0  1   78 000  20          17500      1000                           0000    2
0077 10   4  1   1   1   3   1   2   1   2   1   0  0  1   78 000  20          17500      1000                           0000    2
0078 10   1  1                                         1      000  22                                                    0000
0080 10   1  4   1   0   0   0   1   4   0   0   0  0  1        4              00000   00 0000 00    00     0000  0  000         1
0081 10   1  1   2   3   1   1   2   1   0   1   0  0  1   36 000   4           2200           12           0000  0  000 0000    1
0082 10   1  1   1   3   1   2   2   8   0   1   0  0  1   68 000  20                                       0000  0  000 0000
0082 10   2  1   1   3   1   2   2   8   0   1   0  0  1   68 000  20                                       0000  0  000 0000
0083 10   1  1   1           2   2   8       1         1   42 000   8           5000           22                        0000    1
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        **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0083 10  2   1   1           1   2           1         1   42 000   8           5000              22                     0000   2

0084 10  1   1   4   1   3   1   2   1   2   1   0  0  1   96 000 35 16       12000      1000    83      0 3500         0000   1

0085 10  1   1       2   3   2   2   8   0   1   0  0  1   84 000 24            8000       500    52        0000  0  000 0000

0086 10  1           0       0   0   0   0   0   0  0  1  000   3              00000   00 0000    00 00     0000  0  000

0087 10  1   1   1   3   1   1   2   1   0   1   0  0  1   48 000   8  3  2 00  4250   32           31      0 0000  0  000 0000   1

0088 10  1   1   1   3   1   2   2   8       1   0  0  1   64 000 17           7500              72                     0000   1

0088 10  2   1   1   3   1   2   2   8       1   0  0  1   64 000 17           7500              72                     0000   2

0089 10  1   1   1   1   2   2   2   8       1   0  0  1      000   3                                                    0000   1

0090 10  1   1   1   2   3   1   2   1   3   1   0  0  1   72 000 25 16       13600   22  400    72 35   0   80  2  660 0000   1

0090 10  2   1   1   2   3   1   2   1   3   1   0  0  1   72 000 25 16       13600   22  400    72 35   0   80  0  660 0000   1

0090 10  3   1   1   2   3   1   2   1   3   1   0  0  1   72 000 25 16       13600   22  400    72 35   0   80  0  660 0000   2

0090 10  4   1   1   2   3   1   2   1   3   1   0  0  1   72 000 25 16       13600   22  400    72 35   0   80  0  660 0000   2

0090 10  5   2   7   0   0   0   0   0   0   0   0  0  2            00 00 00 24 00000   00 0000    00 00   0 0000  0  000  600

0090 10  6   2   7   0   0   0   0   0   0   0   0  0  2            00 00 00 24 00000   00 0000    00 00   0 0000  0  000  720

0091 10  1   1   1   2   2   1   2   1   1   2   0  0  1   54 000 22 16 16    10800   32  350    57 37   0 1000  2  648 0000   1

0091 10  2   1   1   2   2   1   2   1   1   2   0  0  1   54 000 22 16 16    10800   32  350    57 37   0 1000  2  648 0000   1

0091 10  3   1   1   2   2   1   2   1   1   2   0  0  1   54 000 22 16 16    10800   32  350    57 37   0 1000  2  648 0000   2

0091 10  4   1   1   2   2   1   2   1   1   2   0  0  1   54 000 22 16 16    10800   32  350    57 37   0 1000  2  648 0000   2

0091 10  5   1   1   2   2   1   2   1   1   2   0  0  1   54 000 22 16 16    10800   32  350    57 37   0 1000  2  648 0000   3

0091 10  6   1   1   2   2   1   2   1   1   2   0  0  1   54 000 22 16 16    10800   32  350    57 37   0 1000  2  648 0000   3

0092 10  1   1               1   2                     1   66 000 15           7500              50                     0000   1

0092 10  2   1                                         1      000 15                                                    0000

0092 10  4   3   1   0   5   0   0   0   0   0   0  0  1  000  22              00000   00 0000    00 00     0000  0  000

0092 10  5   3   1   0   5   0   0   0   0   0   0  0  1  000  22              00000   00 0000    00 00     0000  0  000 3850

0093 10  1   1   1   2   3   2   2   8   2   1   0  1  1   72 000 22  8 00 00 12000   16  730    93 32   0 6000  1      0000   1
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            **********FURNACE CLASSIFICATION**********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL UX FCE FCE HLD MLT MT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS PDWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O     DR  IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP  CH DR DR PRE SIZE LOC AFT SPLY  SYS

0093 10   2  1   1   2   3   2   2   8   2   1   0  1  1   72 000 22   8 00 00 12000  16   730  93   32  0  6000  1      0000   2

0093 10   3  3       0   0   0   0   0   0   0   0  0  3  000  14 00  00 00  8 00000  00  0000  00   00  0  0000  0  000 1825   0

0093 10   4  3       0   0   0   0   0   0   0   0  0  3  000  14 00  00 00  8 00000  00  0000  00   00  0  0000  0  000 1825   0

0094 10   1  1   4   1   3   1   2   2   0   1   0  0  1  112 000 30  17 17    12000  30   900  99   43     0000  0  000 0000   1

0094 10   2  1   4   1   3   1   2   2   0   1   0  0  1  112 000 30  17 17    12000  30   900  99   43     0000  0  000 0000   1

0094 10   3  4   1   0   0   0   1   4   0   0   0  0  1   96   8  4   9  8    00000  00  0000  00   00  0  0000  0  000 3000   2

0095 10   1  1   1   3   1   1   2   1   0   1   0  0  1  102 000 25           13000            55       0  0000  0  000 0000   1

0095 10   2  1   1   3   1   1   2   1   0   1   0  0  1  102 000 25           13000            55       0  0000  0  000 0000   1

0095 10   3  1   1   3   1       2                     1  102 000 25                                                     0000

0095 10   4  1   1   3   1       2                     1  102 000 25                                                     0000

0096 10   1  1   1           1   2   1       2         1  102 000 15            2700             8                       0000   1

0097 10   1  1   1   3   1   1   2   1   0   1         1   28 000 .4            1725             3          0000  0  000 0000   1

0098 10   1  1   4   1   3   1   2   1       1   0  0  1  102 000 40           20000       800  90                       0000   1

0098 10   2  1   4   1   3   1   2   1       1   0  0  1  102 000 40           20000       800  90                       0000   1

0098 10   3  4   1   0   0   0   0       0   0   0  0  2  240  60              00000  00  0000  00   00  0  0000  0  000 8000

0098 10   4  3   1   0   5   0   0   0   0   0   0  0  1  000  23              00000  00  0000  00   00     0000  0  000 3200

0098 10   5  3   1   0   5   0   0   0   0   0   0  0  1  000  23              00000  00  0000  00   00     0000  0  000 3200

0099 10   1  1   4   1   3   1   2   2   0   1   0  0  1   54 000 12  20        6200  64  1000  69       0  0000  0  000 0000   1

0099 10   2  1   4   1   3   1   2   2   0   1   0  0  1   54 000 12  20        6200  64  1000  69       0  0000  0  000 0000   1

0099 10   3  2       0   0   0   0   0   0   0   0  0  3  000  20              00000  00  0000  00   00  0  0000  0  000

0100 10   1  6   0   0   0   0   0   0   0   0   0  0  1  000  80              00000  00  0000  00   00     0000  0  000

0101 10   1  1   2           1   2                     1   60 000 14            8700            14                       0000   1

0101 10   2  1   2           1   2                     1   60 000 14            8700            14                       0000   1

0102 10   1  1                       1                 1   72 000 10            4000                                     0000   1

0103 10   1  1                                         1      000 10                                                     0000
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                                                         FURNACE  DATA                                          PAGE  14
            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR DT ******BLAST**** SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR  IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0103 10   2   1                                        1      000  12                                                   0000
0103 10   3   4  1   0   0   0           0   0   0  0           3              00000  00  0000 00   00     0000  0  000
0103 10   4   4  1   0   0   0           0   0   0  0          .6              00000  00  0000 00   00     0000  0  000
0104 10   1   1  1   3   1   1   2   1   2   2   0  0  1   54 000   9  3        4700  20             35           2  360 0000   1
0105 10   1   1              1   2                     1   54 000   8           6000                                    0000   1
0105 10   2   1              1   2                     1   54 000   8                                                   0000
0105 10   3   3      0       0   0   0   0   0   0  0     000  .5              00000  00  0000 00   00     0000  0  000
0105 10   4   3      0       0   0   0   0   0   0  0     000  .5              00000  00  0000 00   00     0000  0  000
0106 10   1   1  1           2   2   8       1         1   42 000   8                            5                       0000   1
0107 10   1   1  1   3   1   2   2   8   0   1   0  0  1   48   4   8  4  4 00  7000  21       27    8  0  0000  0  000 0000
0108 10   1   1  2           1   2           1         1      000   8           3800            10                       0000   1
0108 10   2   1  1           1   2                     1      000   7           3700            10                       0000   1
0108 10   3   3      0       0   0   0   0   0   0  0     000       5          00000  00  0000 00   00     0000  0  000
0109 10   1   1              1   2           1         1   36 000   5           4000            12                       0000   1
0109 10   2   1              1   2           1         1   36 000   5           4000            12                       0000   2
0109 10   3   1              1   2           1         1   36 000   5           4000            12                       0000   2
0109 10   4   4  1   0   0   0           0   0   0  0       36       5          00000  00  0000 00   00     0000  0  000        3
0110 10   1   1  1   3   1   1   2   1   0   1   0  0  1   84 000  18           9500                           0000  0  000 0000   1
0110 10   2   1  1   3   1   1   2   1   0   1   0  0  1   84 000  18           9500                           0000  0  000 0000   1
0110 10   3   6  0   0   0   0   0   0   0   0   0  0  3  000  50  00 00       00000  00  0000 00   00  0  0000  0  000
0110 10   4   6  0   0   0   0   0   0   0   0   0  0  1  000  50  00 00       00000  00  0000 00   00  0  0000  0  000
0111 10   1   1                                        1      000  12                                                   0000   1
0112 10   1   1  1           2   2   8       1         1   54 000  10           4600            55                       0000   1
0113 10   1   1  1   2   3   2   2   8   0   1   0  1  1   36 000  10 10  9     3950  16   600 18   27  0  0000  0  000 0000   1
0113 10   2   1  1   2   3   2   2   8   0   1   0  1  1   36 000  10 10  9     3950  16   600 18   27  0  0000  0  000 0000   2
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                                           FURNACE  DATA

            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG  FL  OX FCE FCE HLD MLT  MT  PR  OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR  IN  EN USE DIA CAP RAT  UT  UT  UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0113 10   3   6   0   0   0   0   0   0   0   0   0   0   3 000  12  00             00000   00 0000 00    00   0 0000   0 000 0000    0
011J 10   4   2   6   0   0   0   0   0   0   0   0   0   2 000  25  00  10  18     00000   00 0000 00    00   0 0000   0 000  600    0
0114 10   1   1   1   2   3   1   2   1   0   1   0   0   1  60 000  18             18500       750 80         0 0000   0 000 0000    1
0114 10   2   1   1   2   3   1   2   1   0   1   0   0   1  60 000  18             18500       750 80         0 0000   0 000 0000    1
0115 10   1   1   2                           1           1  36 000   5              2800          31                        0000    1
0115 10   2   2   2                           1           1  36 000   5              2800          31                        0000    2
0115 10   3   2   2                                       1     000                                                          0000
0115 10   4   1   2                                       1     000                                                          0000
0116 10   1   1   4           2   2   8   3   1   0   0   1  50 000   9   9          4400          54    30   0 1050   1     0000    1
0116 10   2   1   4           2   2   8   3   1   0   0   1  50 000   9   9          4400          54    30   0 1050   1     0000    2
0117 10   1   1   1   2   3   1   2   1   2   1   0   0   1     000  32                         750                            0000
0117 10   2   1   1   2   3   1   2   1   2   1   0   0   1     000  32                         750                            0000
0117 10   3   6   0   0   0   0   0   0   0   0   0   0   3 000  34  00  00         00000   00 0000 00    00   0 0000   0 000
0117 10   4   6   0   0   0   0   0   0   0   0   0   0   3 000  34  00  00         00000   00 0000 00    00   0 0000   0 000
0118 10   1   1   4   2   3   2   2   8   0   1   0   0   1  54 000  12              6000          48           0000   0 000 0000    1
0118 10   2   1   4   2   3   2   2   8   0   1   0   0   1  61 000  14              6500          46           0000   0 000 0000    1
0118 10   3   1   1   2   3   2   2   8       1   0   0   1  66 000  16              8000          61                        0000    2
0118 10   4   1   1   2   3   2   2   8       1   0   0   1  66 000  16              8000          61                        0000    2
0118 10   5   1   4   2   3   2   2   8   0   1   0   0   1  60 000  14              6500          55           0000   0 000 0000    3
0119 10   1   1                                           1     000   7                                                      0000
0119 10   2   1               1   2                       1  78 000  10                                                      0000    1
0120 10   1   1   1   3   1   1   2   1       1   0   0   1  32 000   6                                                      0000    1
0120 10   2   1   1   3   1   1   2   1       1   0   0   1  32 000   6                                                      0000    1
0120 10   3   6   0   0   0   0   0   0   0   0   0   0   3 000   6  00  00         00000   00 0000 00    00   0 0000   0 000
0120 10   4   7       0       0   0       0   0   0   0          .5                 00000   00 0000 00    00     0000   0 000
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            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIN BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST**** SIZE  HT CHG  AFT AFT DIS POWR  CTL
NO.  TY NO  TYP TYP DES HTG C/O     T-O     DR  IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0121 10  1   1   1   3   1   2   2   8       1   0  0  1   72 000  12           7500           53                        0000   1

0121 10  2   1   1   3   1   2   2   8       1   0  0  1   60 000  12           7500           45                        0000   2

0121 10  3   1   1   3   1   2   2   8       1   0  0  1      000   6                                                    0000

0121 10  4   4   1   0   0   0           0   0   0  0               3          00000  00  0000 00    00     0000  0  000

0122 10  1   1   1   3   1   1   2   1   1   1   0  0  1   48 000   8           3800           22                 1      0000   1

0123 10  1   1   1           1   2           1         1   36 000   6                           7                        0000   1

0124 10  1   1   2           1   2           1         1   36 000   4                           8                        0000   1

0125 10  1   1   4   1   3   1   2   1   2   1   0  0  1  108 000  35  9       15500      1000 92        4  5250  1  484 0000   1

0125 10  2   1   4   1   3   1   2   1   2   1   0  0  1  108 000  35  9       15500      1000 92        4  5250  1  484 0000   1

0125 10  3   1                                         1      000                                                        0000

0125 10  4   1                                         1      000  20                                                    0000

0125 10  5   1                                         1      000  20                                                    0000

0125 10  6   1                                         1      000  12                                                    0000

0126 10  1   1   4   1   3   1   2   1   0   1   0  0  1  102 000  40 17    00 20000  42  1200 99        0  0000  0  000 0000   1

0126 10  2   3       0   0   0   0   0   0   0   0  0  2  000  23     00 00 17 00000  00  0000 00    00  0  0000  0  000 1500   0

0126 10  3   3       0   0   0   0   0   0   0   0  0  2  000  23     00 00 17 00000  00  0000 00    00  0  0000  0  000 1500   0

0126 10  4   3       0   0   0   0   0   0   0   0  0  2  000  23     00 00 17 00000  00  0000 00    00  0  0000  0  000 1500   0

0126 10  5   3       0   0   0   0   0   0   0   0  0  2  000  23     00 00 17 00000  00  0000 00    00  0  0000  0  000 1500   0

0127 10  1   1   1           1   2           1         1   40 000   6                           8                        0000   1

0128 10  1   1   1           1   2           1         1   36 000   5           1600            5                        0000   1

0129 10  1   1               1   2                     1      000   9                          30                        0000   1

0130 10  1   1   2           1   2   1       2         1   45 000   9           4000           30                        0000   1

0132 10  1   1   1           1   2   1       1         1   78 000  12  8        7500           35                        0000   1

0132 10  2   1   1           1   2   1       1         1   60 000  12  8        7500           35                        0000   1

0133 10  1   1   1   3   1   2   2   8   0   1   0  0  1   42 000   7                                       0000  0  000 0000
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                                                        FURNACE  DATA
            **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP  CH DR DR PRE SIZE LOC AFT SPLY  SYS

0133 10   2  1   1   3   1   2   2   8   0   1  0  0   1   42 000  7                                        0000  0  000 0000

0133 10   3  7   0   0   0   0   0   0   0   0  0  0           .5              00000  00  0000  00   00     0000  0  000

0134 10   1  1   4   1   3   1   2   1       1  0  0   1   84 000 60  16        15000       1000                           0000   1

0134 10   2  1   4   1   3   1   2   1       1  0  0   1   84 000 60  16        15000       1000                           0000   1

0135 10   1  1   2           1   2                     1   52 000  4             3000                                     0000   1

0136 10   1  1   1   2   3   1   2   1   0   1  0  0   1   63 000 16  18    00  5500  14   700  45       0  0000  0  000 0000   1

0136 10   2  1   1   2   3   1   2   1   0   1  0  0   1   63 000 16  18    00  5500  14   700  45       0  0000  0  000 0000   1

0136 10   3  6   0   0   0   0   0       0   0  0  0   3  000   30 14  00 16 00 00000  00  0000  00   00  0  0000  0  000 0000   0

0137 10   1  1   1   1   3   2   2   8       1  0  0   1   72 000 18           10700       1000  69                       0000   1

0137 10   2  1   1   1   3   2   2   8       1  0  0   1   72 000 18           10700       1000  69                       0000   2

0137 10   3  1   1   1   3                             1      000 25                      1000                           0000

0137 10   4  1   1   1   3                             1      000 25                      1000                           0000

0138 10   1  1       3   1   1   2                     1   60 000 10             3600              17                       0000   1

0138 10   2  1                                         1      000  6                                                     0000

0139 10   1  1   1   3   1   1   2                     1   60 000 16             6400              50                       0000   1

0140 10   1  1   1   3   1   1   2   1       1  0  0   1   54 000  7             5300              37                       0000   1

0140 10   2  1   1   3   1   1   2   1       1  0  0   1   54 000  7             5300              37                       0000   1

0141 10   1  1   1   1       1   2           1         1   54 000 12             6000              40                       0000   1

0141 10   2  1   1   1       1   2           1         1   54 000 12             6000              40                       0000   1

0141 10   3  4   1   0   0   0           0   0  0  0                           00000  00  0000  00   00     0000  0  000

0141 10   4  3       0       0   0   0   0   0  0  0      000                  00000  00  0000  00   00     0000  0  000

0141 10   5  3       0       0   0   0   0   0  0  0      000                  00000  00  0000  00   00     0000  0  000

0141 10   6  3       0       0   0   0   0   0  0  0      000                  00000  00  0000  00   00     0000  0  000

0141 10   7  3       0       0   0   0   0   0  0  0      000                  00000  00  0000  00   00     0000  0  000

0142 10   1  1                                         1      000  5                                                     0000   1
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                                                         FURNACE  DATA                                             PAGE  18
            **********FURNACE CLASSIFICATION**********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST**** SIZE  HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  ND TYP TYP DES HTG C/O     T-O     DR  IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS
0143 10   1  1               1   2                     1      000  8                                                     0000   1
0144 10   1  1       3   1   1   2                     1   43 000  9            4800              8                       0000   1
0145 10   1  1   1           1   2   1       1         1   48 000  5            4200             21                       0000   1
0146 10   1  1   1   3   1   1   2   1   0   2  0  1   1  108 000 55  16 00 00 16500 40         91   38  0  0000  0  000 0000   1
0146 10   2  1   1   3   1   1   2   1   0   2  0  1   1  108 000 55  16 00 00 16500 40         91   38  0  0000  0  000 0000   1
0147 10   1  1   1           2   1   8   0   0  0  0   1   70 000 20                                        0000  0  000 0000
0147 10   2  1   1           2   1   8   0   0  0  0   1   70 000 20                                        0000  0  000 0000
0147 10   3  1   1           2   1   8   0   0  0  0   1   70 000 55                                        0000  0  000 0000
0147 10   4  1   1           2   1   8   0   0  0  0   1   70 000 55                                        0000  0  000 0000
0147 10   5  1   1           2   1   8   0   0  0  0   1   70 000 55                                        0000  0  000 0000
0148 10   1  1                                         1      000 35                                                     0000
0148 10   2  1                                         1      000 35                                                     0000
0149 10   1  1   1                                     1      000 13                                                     0000
0149 10   2  1   1                                     1      000 13                                                     0000
0150 10   1  1   1   2   2   1   1   2   3   2  0  1   1   78 000 38   9       11000 40    700        21  0  4250  1  150 0000   1
0150 10   2  1   1   2   2   2   1   2   3   2  0  1   1   78 000 38   9       11000 40    700        21  0  4250  1  150 0000   1
0151 10   1  1   4   1   3   1   2   1   0   1  0  0   1   96 000 25           12500 24   1000  60          0000  0  000 0000   1
0152 10   1  1   1   3   1   1   2   1       1  0  0   1   60 000 22           10500                                     0000   1
0152 10   2  1   1   3   1   1   2   1       1  0  0   1   60 000 22           10500                                     0000   1
0153 10   1  1   1   2   3   2   2   8   0   1  0  0   1   50 000 22                       700              0000  0  000 0000
0153 10   2  1   1   2   3   2   2   8   0   1  0  0   1   50 000 22                       700              0000  0  000 0000
0153 10   3  6   0   0   0   0   0   0   0   0  0  0   3  000  35           00000 00   0000  00   00     0000  0  000
0153 10   4  6   0   0   0   0   0   0   0   0  0  0   3  000  35           00000 00   0000  00   00     0000  0  000
0153 10   5  3       0       0   0   0   0   0  0  0        000   9  3           00000 00   0000  00   00     0000  0  000 1600
0153 10   6  3       0       0   0   0   0   0  0  0        000   9  3           00000 00   0000  00   00     0000  0  000 1600
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        **********FURNACE CLASSIFICATION*********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR CTL
 NO. TY  NO TYP TYP DES HTG C/O     T-O      DR IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY SYS

0154 10   1   1   1   3   1   2   2   8   0   1  0  0   1  48 000   6                                       0000   0 000 0000
0:54 10   2   1   1   3   1   2   2   8   0   1  0  0   1  60 000  15                                       0000   0 000 0000
0154 10   3   1   1   3   1   2   2   8   0   1  0  0   1  60 000                                           0000   0 000 0000
0155 10   1   1   1                                     1     000   5                                                    0000
0156 10   1   1   1   2   3   2   2   8   2   1  0  0   1  66 000  23                      750                           0000   1
0157 10   1   1               1   2           2         1  37 000   4           2700              20                     0000   1
0158 10   1   1   1   3   1   2   2   8       1  0  0   1  88 000  21          15000              60                     0000   1
0159 10   1   1       3   1   1   2                     1  42 000   6           3400              14                     0000   1
0160 10   1   1   4   3   1   1   2   1   0   1  0  0   1  90 000  34 16 16 00 14000   54         99      0 0000   0 000 0000   1
0160 10   2   1   4   3   1   1   2   1   0   1  0  0   1  90 000  34 16 16 00 14000   54         99      0 0000   0 000 0000   1
0160 10   3   1   1   1       2   2   8   0   1  0  0   1  68 000  23 16 16 00         35         60      0 0000   0 000 0000   0
0160 10   4   1   1           2   2   8   0   1  0  0   1  68 000  23 16 16 00         35         60      0 0000   0 000 0000   0
0160 10   5   1   1   0       2   2   8   0   1  0  0   1  68 000  23 16 16 00 00000   35 0000    60      0 0000   0 000 0000   0
0160 10   6   1   1   0       2   2   8   0   1  0  0   1  68 000  23 16 16 00 00000   35 0000    60      0 0000   0 000 0000   0
0160 10   7   2   5   0   0   0   0   0   0   0  0  0   2 000  35  00 00 16 24 00000   00 0000    00 00   0 0000   0 000  600   0
0160 10   8   2   5   0   0   0   0   0   0   0  0  0   2 000  30  00 00 16 24 00000   00 0000    00 00   0 0000   0 000  600   0
0160 10   9   2   5   0   0   0   0   0   0   0  0  0   2 000  25  00 00 16 24 00000   00 0000    00 00   0 0000   0 000  600   0
0161 10   1   1               1   2                     1  54 000   4           6000                                     0000   1
0161 10   2   1                                         1  54 000   4                                                    0000
0161 10   3   7               0   0       0   0  0  0          .5              00000   00 0000    00 00     0000   0 000
0162 10   1   1   1           1   2       0             1     000               3500                        0000   0 000 0000   1
0163 10   1   1   1   3   1   1   2   1       1  0  0   1  54 000  15           9000                                     0000   1
0163 10   2   1   1   3   1   1   2   1       1  0  0   1  54 000  15           9000                                     0000   1
0165 10   1   4   1   0   0   0   1   3   0   0  0  0   1  96         5  8       00000   00 0000    00 00   0 0000   0 000 4500   1
0165 10   2   4   1   0   0   0   1   3   0   0  0  0   1  96         5  8       00000   00 0000    00 00   0 0000   0 000 4500   1
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                                                         FURNACE  DATA                                            PAGE   20

            **********FURNACE CLASSIFICATION**********
FDRY CD FCE FCE LIV BLT BLT TOP CHG GAS AFT CHG FL OX FCE FCE HLD MLT MT PR OT ******BLAST****  SIZE HT CHG  AFT AFT DIS POWR  CTL
 NO. TY  NO TYP TYP DES HTG C/O      T-O     DR  IN EN USE DIA CAP RAT UT UT UT VOLUM PRES TEMP CH DR DR PRE SIZE LOC AFT SPLY  SYS

0165 10   3   2   6   0   0   0   0   0   0   0  0  0   2 000  20 00       8 16 00000 00   0000 00    00 0   0000 0   000  500   0

0165 10   4   2   6   0   0   0   0   0   0   0  0  0   2 000  20 00       8 16 00000 00   0000 00    00 0   0000 0   000  500   0

0166 10   1   6   0   0   0   0   0   0       0  0  0   1  48      10          00000 00   0000 00    00                  0000   1

0167 10   1   1   1   2   3   2   2   8   1   1  0  0   1  70 000 22          10000        550 40                1       0000   1

0167 10   2   1   1   2   3   2   2   8   1   1  0  0   1  70 000 22          10000        550 40                1       0000   2

0168 10   1   1   1   3   1   1   2   1   0   1  0  0   1  40 000  7   6 00 00  3500 35           9       0   0000 0   000 0000   1
```

APPENDIX B
EXHIBIT I
SECTION 3 PAGE 1

MELTING OPERATION

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FDRY CD FCE TOTAL  REMELT PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA FLOU OTH CARB FE-  MN ADDIT ME/CO SUL D Q C S  LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH        IRON CST I STEEL      TURN STN MITE ASH  SPAR ER  COKE SIL      T LBS RATIO CON A S M P  TIME METH
0001 20  1                                                                   000                  8
0001 20  2                                                                   000                  8
0001 20  3                                                                   000                  7
0001 20  4                                                                   000                  7
0002 20  1                                                                   000                  9
0002 20  2                                                                   000                  9
0004 21  2    6000    6000 0000 0000  00000 000 0000 000 000   00   00   00  000  000 00 0 000   00   00 0 4 0 0  000   0  00 00  00
0004 21  3   39600   21500 0000 0000  16000 000 2000     200   00   00   00  450  500 00 0 000   00   00 0 2 6 0  000   0  00 00  00
0004 21  4   39600   21600 0000 0000  16000     2000                         450  500 00 0 000   00   00 0 2 6 0  000   0  00 00  00
0004 21  5   39600   21500 0000 0000  16000     2000     200                 450  500 00 0 000   00   00 0 2 6 0  000   0  00 00  00
0005 20  1                                                                   000                  8
0007 20  1    2500     500 0000 1500    500 000 0000  70 000   00   00   00  000  000 00 0 000    9   .6 0 3 2 0   30   2
0008 20  1    4000    1500 0000 2200    300 000 0000 115 000   00   00   00  000  000 00 0 000    7   .6 0 3 2 0  100   2
0009 20  1   22000    8360                                                   000  150            10        3 2          1
0009 20  2   22000    8360                                                   000  150            10        3 2          1
0011 20  1                                                                   000                  6
0012 20  1    7000    1000 1000 4500    500 000 0000 200 000   00   00   00  000  000 20 0 000   12   .6 2 2 3 3  120   6  10 14  65
0012 22  2    5400     700  700 0000   4000 000 0000 250 000   00   00   00  000  000 00 0 000    9   .6 2 1 3 3  120   6  16 12  68
0012 20  3    2500   00000  900 0000    800 800 0000  80 000   00   00   00  000   35 15 0 000    8   .6 0 1 3 3  120   6  18 14  63
0012 22  4    1500   00000  600 0000    900 000 0000  45 000   00   30   00  000   45 00 2 550    5   .6 0 1 3 3  120   6
0012 20  5     200      60 0000 0000    140 000 0000  12 000   00   00   00  000   12 00 1   1    6   .6 0 1 3 3  120   6
0013 20  1                                                                   000                 18
0014 20  1    2000   00000  687 1250  00000 *63 0000  60                     000                  7   .7
0014 20  2    2000   00000  687 1250  00000 *63 0000  60                     000                  7   .7
0015 20  1                                                                   000                 12
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                                                      MELTING  OPERATION
                                                                                                                     PAGE    2
FDRY CD FCE TOTAL  REMELT PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA FLOU OTH CARB FE-  MN ADDIT ME/CO SUL D Q C S  LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH         IRON CST I STEEL     TURN STN MITE ASH  SPAR ER   COKE SIL    T LBS RATIO CON A S M P  TIME METH
0016 20   1                                                                  000                10
0016 20   2                                                                  000                10
0018 20   1  1000    500  0000 0000    400 000  0000  40 000   00   00  00   000  000 00 3   2   6
0018 20   2  1300    500  0000 0000    400 000  0000  40 000   00   00  00   000  000 00 3   2   6
0021 20   1                                000  0000                         000  000 00 0 000  10   .6  0 4 2 0  20   6
0021 22   1  2275   1000    75 0000   1200 000  0000 120 000   00   30  00   000  000  3     5   7   .6  0 4 2 0  20   6
0021 20   2                                                                  000  000 00 0 000  10   .6  0 4 2 0  20   6
0021 22   2  2275   1000    75 0000   1200 000  0000 120 000   00   30  00   000  000  3     5   7   .6  0 4 2 0  20   6
0022 20   1  2500   1000   100 0000   1400 000  0000                                                00   00      0 1           00 00  00
0022 20   2  2500   1000   100 0000   1400 000  0000                                                00   00      0 1           00 00  00
0022 20   3  2500   1000   100 0000   1400 000  0000                                                00   00      0 1           00 00  00
0022 20   4  2500   1000   100 0000   1400 000  0000                                                00   00      0 1           00 00  00
0025 20   1  4000    400  0000 0000   2000      0000 125 000   00   00  00   000  000 00 0 000   6         3               16  3  78
0026 20   1  2000    200  0000 1500    300 000  0000  75 000   00    2  00   000     12 0 000    8   1.  0 3 3 0 120   1
0026 20   2  2000    200  0000 1500    300 000  0000  75 000   00    2  00   000     12 0 000    8   1.  0 3 3 0 120   1
0027 20   1  4000   1600   800 0000   1500 100  0000 130 000   00   00  00   000        0 000    7   .6  2 2   0  30   2       8
0029 20   1  3000    750   *62 1050    450 750  0000     125            25                       6       0 3 3 0  60   6
0031 20   1  4000   1000  1000 2000                   80 000   00   00  00   000  000 00 0 000  10       0
0031 20   2  4000   1000  1000 2000                   80 000   00   00  00   000  000 00 0 000  10       0
0032 21   1  1935    800  0000 0000   1135 000  0000  60 000    5   00  00   000     65         12   .6  0 1 2 0  60   1
0033 20   1                                                                  000                 7
0033 20   2                                                                  000                 7
0034 20   1                900 3600   4500           200                     000                 8
0035 20   1  1800    400   230  200  00000 750   200 120 000   00    5  00   000  40  4 0 000    8   .6  0 3 3 3       5
0035 20   2  1800    550   230  200  00000 600   200  90 000   00    3  00   000  40  2 0 000    8   .6  0 3 3 3       5
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                                                     MELTING  OPERATION                                             PAGE   3
FDRY CO FCE TOTAL  REMELT PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA FLOU OTH CARB FE- MN ADDIT  ME/CO SUL D Q C S  LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH         IRON CST I STEEL      TURN STN MITE ASH  SPAR ER   COKE SIL    T LBS  RATIO CON A S M P TIME METH

0035 20   3  1800    550   230  200  00000 600   200  90 000   00    3  00  000   40  2 0 000    8   .6  0 3 3 3       5

0036 20   1                                                                 000                  6

0037 20   1                                                                 000                  6                90   1

0042 20   1  4000   1200  0000 0000    800      0000 000  12   00   00  00  000  136  4 0 000    8       0 3 5 0  90   2

0043 20   1  1500    400   475  500  00000 125  0000  80 000   00   00  00  000    6 00 0 000    6       0 3 2 0  60   1

0045 20   1                                                                 000                  9

0045 20   2                                                                 000                  9

0045 20   3                                                                 000                  9

0045 20   4                                                                 000                  9

0045 20   5                                                                 000                  9

0045 20   6                                                                 000                  9

0045 20   7                                                                 000                  9

0045 20   8                                                                 000                  9

0046 22   1 30000  15000  0000 0000  15000 000  0000 000 000   00   00  00  600  000 00 0 000   00   00    4 3 0 000   0   00 00  00

0046 22   2 30000  15000  0000 0000  15000 000  0000 000 000   00   00  00  600  000 00 0 000   00   00    4 3 0 000   0   00 00  00

0046 22   3 30000  15000  0000 0000  15000 000  0000 000 000   00   00  00  600  000 00 0 000   00   00    4 3 0 000   0   00 00  00

0046 22   4 30000  15000  0000 0000  15000 000  0000 000 000   00   00  00  600  000 00 0 000   00   00    4 3 0 000   0   00 00  00

0047 20   1                                                                 000                 10

0047 20   2                                                                 000                 10

0048 20   1 32000  15000  0000 5000  10000 000  1000 000 000   00   00  00  550  250 25         00   00    3 3 0 000   0   00 00  00

0049 20   1                                                                 000                            3

0052 20   1  4000   1500  1600  800  00000 *75  0000  60 000   00   00  00  000  000 00 0 000   10   .6  2 2   0  90   2   12 14  74

0052 20   2  4000   1500  1600  800  00000 *75  0000  60 000   00   00  00  000  000 00 0 000   10   .6  2 2   0  90   2   12 14  74

0052 20   3  4000   1500  1600  800  00000 *75  0000  60 000   00   00  00  000  000 00 0 000   10   .6  2 2   0  90   2   12 14  74

0052 20   4  4000   1500  1600  800  00000 *75  0000  60 000   00   00  00  000  000 00 0 000   10   .6  2 2   0  90   2
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                                              MELTING  OPERATION                                                 PAGE   4

FORY CD FCE TOTAL  REMELT PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA FLOU OTH CARB FE- MN ADDIT ME/CO SUL D Q C S  LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH        IRON CST I STEEL      TURN STN MITE ASH  SPAR ER  COKE SIL    T LBS RATIO CON A S M P TIME METH

0061 20   1  3000   1300   600  300    800 000  0000 000  60   00   00  00  000  000  6 0 000    9  .6  0 1   0   90   2

0062 20   1                                                                 000                10

0062 20   2                                                                 000                10

0065 20   1  5870  00000  0000 3170   2700 000  0000 170 000   00   00  00  000  170 00 0 000    8          2 0

0065 20   2  5870  00000  0000 3170   2700 000  0000 170 000   00   00  00  000  170 00 0 000    8          2 0

0066 20   5 10000   4000  1450        2000      0000                        000

0067 20   1                                                                 000                     .6                 1

0067 20   2                                                                 000                     .6                 1

0067 20   3                                                                 000                     .6                 1

0070 20   1                                                                 000                  5

0070 20   2                                                                 000                  5

0070 20   3                                                                 000                  5

0070 20   4                                                                 000                  5

0070 20   5                                                                 000                  5

0072 20   1                                                                 000                                  120   2   00 00  00

0072 20   2                                                                 000                                  120   2   00 00  00

0072 20   3                                                                 000                                  120   2   00 00  00

0072 20   4                                                                 000                                  120   2   00 00  00

0072 20   5                                                                 000                                  120   2   00 00  00

0072 20   6                                                                 000                                  120   2   00 00  00

0074 20   1                                                                 000                  8

0076 20   1                                                                 000                  7

0081 20   1                                                                 000                  5

0083 20   1                                                                 000                  9

0083 20   2                                                                 000                  9
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MELTING OPERATION

FDRY NO.	CD TY	FCE NO	TOTAL MTL CH	REMELT	PIG IRON	PURCH CST I	PURCH STEEL	BRIQ	PUN/ TURN	LIM STN	DOLO MITE	SODA ASH	FLOU SPAR	OTH ER	CARB COKE	FE- SIL	MN	ADDIT T	LBS	ME/CO RATIO	SUL CON	D A	Q S	C M	S P	LITE-UP TIME	METH	CO	CO2	N2
0084	20	1	4000	00000	0000	400	3600	000	0000	300	000	00	30		000	150	00	4	10	7	.6							11	13	76
0085	20	1	2950	1000	900	0000	1050	000	0000	120	000	00	00	00	000	50	00	0	000	11								3	13	82
0087	20	1	1000	450	275	0000	275	000	0000	26	000	00	00	00	000	5	3	0	000	8	.5	0	4	1	1	90	6			
0088	20	1	2000	00000	*250	150	1600	000	0000	70	000	00	4	00	000	8	12	0	000	8						45				
0088	20	2													000					8										
0090	20	1	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0090	20	2	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0090	20	3	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0090	20	4	4200	1495	1200	260	600	500	*125	125	000	00	00	00	000	000	00	0	000	11	.6	0	3	3	0	45	1			
0091	20	1	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	2	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	3	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	4	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	5	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0091	20	6	4000	1400	900	500	1000	200	0000	110	000	00	00	00	000	26	20	5	30	11	.6	0	3	3	0	90	1			
0092	21	1													000					9										
0093	20	1	5500	1100	0000	1650	2750	000	0000	70	000	00	00	00	000	75	00	0	000	8	.6	2	1	3	0	120	2		13	
0093	22	1	6000	1200	0000	0000	4800	000	0000	90	000	00	00	5	000	100	00	0	000	18	.6	2	4	3	0	120	2			
0093	20	2	5500	1100	0000	1650	2750	000	0000	70	000	00	00	00	000	75	00	0	000	8	.6	2	1	3	0		2		13	
0093	22	2	6000	1200	0000	0000	4800	000	0000	90	000	00	00	5	000	100	00	0	000	8	.6	2	4	3	0	120	2			
0093	20	3	00000	00000	0000	0000	00000	000	0000	000	000	00	00	13	000	000	00	3	11	00	00	0	0	0	0	000	0	00	00	00
0093	22	3	00000	00000	0000	0000	00000	000	0000	000	000	00	00	8	000	000	00	3	13	00	00	0	0	0	0	000	0	00	00	00
0093	20	4	00000	00000	0000	0000	00000	000	0000	000	000	00	00	13	000	000	00	3	11	00	00	0	0	0	0	000	0	00	00	00
0093	22	4	00000	00000	0000	0000	00000	000	0000	000	000	00	00	8	000	000	00	3	13	00	00	0	0	0	0	000	0	00	00	00
0094	20	1	6500	1400	0000	2500	2600	000	0000	000	100	00	00	00	000	35	00	0	000	9	.6	2	3	3	0	240	2	16	13	71

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                                                      MELTING  OPERATION                                              PAGE     6

FDRY CD FCE TOTAL  REMELT  PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA  FLOU OTH CARB FE-  MN ADDIT ME/CO SUL  D Q C S  LITE-UP   CO CO2 N2
 NO. TY  NO MTL CH         IRON CST I STEEL      TURN STN MITE ASH   SPAR ER  COKE SIL     T LBS RATIO CON  A S M P  TIME METH

0094 22   1  5000     750  0000 0000   4250 000  0000 000   80   00   00  00  000   40  00 0 000   6   .6   2 2 3 0 240   2    16 13  71

0094 20   2  6500    1400  0000 2500   2600 000  0000 000  100   00   00  00  000   35  00 0 000   9   .6   2 3 3 0 240   2    16 13  71

0094 22   2  5000     750  0000 0000   4250 000  0000 000   80   00   00  00  000   40  00 0 000   6   .6   2 2 3 0 240   2    16 13  71

0094 20   3  7200    1550  1550 0000   4100 000  0000 000  000   00   00  00       000  00 0 000  00   00   0 0 3 0 000   0    00 00  00

0095 20   1                                                                   000                             3

0095 20   2                                                                   000                             3

0096 20   1                                                                   000                  8

0097 20   1   800   00000   400 0000    400 000  0000                         000

0098 20   1                                                                   000                  7

0098 20   2                                                                   000                  7

0099 20   1  1100     200  0000  700  00000 200  0000  60  000   00   00  00  000  000  00 0 000   6        0 3 3 0       2     3  2  80

0099 20   2  1100     200  0000  700  00000 200  0000  60  000   00   00  00  000  000  00 0 000   6        0 3 3 0       2     3  2  80

0102 20   1                                                                   000                             3

0104 20   1  2000     800   400  200    600            60  000   00   00  00  000                  6   .6   3 4 2 0       2

0106 20   1                                                                   000                  8

0107 20   1  1200     600  0000 0000    600 000  0000  12   .5    4           000    8   4 0 000   8   55   3 4      20   1

0108 20   1                                                                   000                  9

0108 20   2                                                                   000                  9

0109 20   1                                                                   000                 10

0109 20   2                                                                   000                 10

0109 20   3                                                                   000                 10

0110 21   1  2945    1800  0000 0000   1145 000  0000  60  000   00   00  00  000   55  00 6   4  10          3

0110 21   2  2945    1800  0000 0000   1145 000  0000  60  000   00   00  00  000   55  00 5   4  10          3

0113 21   1  1000     580   *80 0000    340 000  0000  20  000   .5   00  00  000  .75  .3 7  .5  11   .7   0 4 1 0  60   2

0113 21   2  1000     580   *80 0000    340 000  0000  20  000   .5   00  00  000  .75  .3 7  .5  11   .7   0 4 1 0  60   2
```

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                                                     MELTING  OPERATION                                           PAGE   7
FDRY CD FCE TOTAL  REMELT PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA FLOU OTH CARB FE- MN ADDIT ME/CO SUL D Q C S  LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH        IRON CST I STEEL      TURN STN MITE ASH  SPAR ER  COKE SIL    T LBS RATIO CON A S M P TIME METH
0114 20   1  2000   1200   200 0000    600 000 0000  75 000   00   00  00  000  000 00 5  23   9         4
0114 20   2  2000   1200   200 0000    600 000 0000  75 000   00   00  00  000  000 00 5  23   9         4
0115 20   1                                                                 000                 6
0115 20   2                                                                 000                 6
0116 20   1  1430    730   400 0000    300 000 0000  60 000   00   00  00  000                 6                        .2  8  71
0116 20   2  1430    730   400 0000    300 000 0000  60 000   00   00  00  000                 6                        .2  8  71
0122 20   1  1280    450   320  125    385 000 0000  60 000   00   00  10  000                 8         4 2        2
0123 20   1                                                                 000                10
0124 20   1                                                                 000                10
0125 20   1                                                                 000                10         3              16 11  72
0125 20   2                                                                 000                10         3              16 11  72
0126 20   1 10000    500  0000 3500   5000 000  900 400 000   00   18  00  000  260 00 0 000   9   .6  3 2 2 0      5
0126 22   1 10000   1000  0000 0000   9000 000  000 400 000   00   18  00  000  210 00 0 000   9   .6  3 2 2 0      5
0127 20   1                                                                 000                 5
0128 20   1                                                                 000                 4
0130 20   1                                                                 000                 9
0132 20   1  1933    735  0000 1265  00000  33 0000  66 000   00   00  00  000                10
0132 20   2  1933    735  0000 1265  00000  33 0000  66 000   00   00  00  000                10
0136 20   1  2500   1250   400  750  00000 100 0000  80 000   00    4  00  000  000 00 5  25  12
0136 21   1  2500   1650  0000 0000    750 100 0000  30 000   00    1  00  000  000  5 5   8   8   .5  2 2 3 0 60   2
0136 20   2  2500   1250   400  750  00000 100 0000  80 000   00    4  00  000  000 00 5  25  12
0136 21   2  2500   1550  0000 0000    750 100 0000  30 000   00    1  00  000  000  5 5   8   8   .5  2 2 3 0 60   2
0137 20   1                                                                 000                10
0137 20   2                                                                 000                10
0141 20   1                                                                 000                 7
```

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                                                        MELTING  OPERATION

FDRY CD FCE TOTAL   REMELT PIG  PURCH  PURCH BRIQ  PUN/ LIM DOLO SODA FLOU OTH CARB FE-  MN ADDIT ME/CO SUL D Q C S  LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH         IRON CST I STEEL        TURN STN MITE ASH  SPAR ER  COKE SIL     T LBS RATIO CON A S M P TIME METH

0141 20  2                                                                     000                 7

0145 20  1                                                                     000                10          4

0146 20  1  8000     560  1760 3680   2000 000   0000 160 000   00    00   00  000   25 00 0 000   9   .6  3 4 2 3 120    2

0146 22  1  8000     800  3200 0000   4000 000   0000 160 000   00    00   00  000   25 00 0 000   8   .6  3 4 2 3 120    2

0146 20  2  8000     560  1760 3680   2000 000   0000 160 000   00    00   00  000   25 00 0 000   9   .6  3 4 2 3 120    2

0146 22  2  8000     800  3200 0000   4000 000   0000 160 000   00    00   00  000   25 00 0 000   8   .6  3 4 2 3 120    2

0150 20  1  6000     900  1500 2700    900 000   0000 130 000   00    00   00  000  000 00 7  20  11   .6  2 1 1 0        6     8 17  76

0150 22  1  5000     500  2250 0000   2250 000   0000 130 000   00    00   00  000   20 00 7 000  10   .6  2 4 1 0        6

0150 20  2  6000     900  1500 2700    900 000   0000 130 000   00    00   00  000  000 00 7  20  11   .6  2 1 1 0        6     8 17  76

0150 22  2  5000     500  2250 0000   2250 000   0000 130 000   00    00   00  000   20 00 7 000  10   .6  2 4 1 0        6

0151 20  1  7060    5250  1050  700  00000 000   0000 200 000   00    00   00  000   60 00 0 000   9   .6      2

0157 20  1                                                                     000                 8

0158 20  1                                                                     000                 9

0160 20  1  5000    2000   600 0000   1900 500   0000 150 000   00    00   00  000      99         8       0 1 3 0        2

0160 20  2  5000    2000   600 0000   1900 500   0000 150 000   00    00   00  000      99         8       0 1 3 0        2

0160 20  3  3764    1700   500 0000   1500  64   0000  90 000   00    00   00  000      30 0 000   9       0 1 3 0        2

0160 20  4  3764    1700   500 0000   1500  64   0000  90 000   00    00   00  000      30 0 000   9       0 1 3 0        2

0160 20  5  3764    1700   500 0000   1500  64   0000  90 000   00    00   00  000      30 0 000   9       0 1 3 0        2

0160 20  6  3764    1700   500 0000   1500  64   0000  90 000   00    00   00  000      30 0 000   9       0 1 3 0        2

0162 20  1  1000     200   300  200    300 000   0000 000 000   00    00   00  000  000 00

0163 20  1  2025                                       70                      000                 8

0163 20  2  2025                                       70                      000                 8

0165 20  1 10000    3600  1000 1700   3000 000    700 000 000   00    00   00  100  120 00 8  30  00   00  3 4 3 0 000    0

0165 22  1 10000    4300  2000 0000   3000 000    700 000 000   00    00   00  100  120 00 8  20  00   00  3 4 3 0 000    0

0165 20  2 10000    3600  1000 1700   3000 000    700 000 000   00    00   00  100  120 00 8  30  00   00  3 4 3 0 000    0
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                                                     MELTING  OPERATION                                             PAGE   9
FDRY CD FCE TOTAL  REMELT PIG  PURCH PURCH BRIQ PUN/ LIM DOLO SODA FLOU OTH CARB FE- MN ADDIT ME/CO  SUL D Q C S LITE-UP  CO CO2 N2
 NO. TY  NO MTL CH        IRON CST I STEEL      TURN STN MITE ASH  SPAR ER  COKE SIL    T LBS RATIO  CON A S M P TIME METH

0165 '2   2 10000    4300 2000 0000   3000 000   700 000 000   00   00  00  100  120 00 8  20  00    00  3 4 3 0 000   0

0166 20   1 14000    6800 5600 0000   1600 LBP  ERHR                CO  AL  100  OLB PE R TON              4           3

0167 20   1  2400    2250 0000 0000    150 000  0000 120 000   00   00  00  000   17 00 0 000   8          4 3         3

0167 20   2  2400    2250 0000 0000    150 000  0000 120 000   00   00  00  000   17 00 0 000   8          4 3         3

0168 20   1   660   00000 0000  255    405 000  0000   6 000   00   00  00  000  000 00 0 000   8          3 2 0 120   1
```

CONTROL SYSTEM

FDRY NO.	CD TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0001	30	1	4	123	58	104000	400	8	87	0000			72	2	0	0		.28		80	15
0002	30	1	27	12	54	45300	550	4	46	9999			25	2	0	0		.039		90	12
0004	30	1	6	345		200000	120	9	13	0000	0000	000	0000	2	3	3			6	99	
0005	30	1	26	1	51	11500	200	4		250				2	3	2		.008		99	7
0006	30	1	6	1	68					0000					3						
0007	30	1	26	1	67	54000	500	6	83	7400	0000	30	30	2	3	2	.86		26	99	20
0008	30	1	26	1	67	38000	500	7	46	3300	0000	20	20	2	3	2		.69	11	99	12
0009	30	1	24	12	67	84000	450		125	8000	0000	000	0000	2	0	0	.65	.13	11	80	
0009	30	2	24	3	67	84000	450		125	8000	0000	000	0000	2	0	0	.678	.163	13	75	13
0010	30	1	6	1	69					0000					3						
0011	30	1	26	1	65	46000	450	6		7800			20	2	3	2					
0012	30	1	4	12	55	101000	500	6	82	0000			200	2	0	0	.5	.075		85	40
0013	30	1	25	1	63	34000	163	12	60	500			140	2	0	0					18
0014	30	1	4	12	68	48000	400		125		0000	000	0000	2	0	0	.311	.153		51	6
0015	30	1	5	1	67	11000	1500	15		0000			2200		0	0		.25		80	6
0016	30	1	23	1	58			00	61	3300			175	2	0	0					
0016	30	2	23	2	58			00	61	3300			175	2	0	0					
0017	30	1	6	12		16500	500								3	2					
0018	30	1	3	1	56	32050	1435	00	45	0000			20		0	0	1.06	.159		85	6
0018	30	2	3	2	56	32050	1435	00	45	0000			20		0	0					
0019	30	1	3	1																	
0019	30	2	3	2																	
0021	30	1	35	12	66	24000			76	0000	175	250	0000	2	0	0		.269	6		18
0023	30	1	4	1	59	36000	500			0000					0	0					
0024	30	1	5	12	67					0000					0	0					

CONTROL SYSTEM

FDRY NO.	CO TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0025	30	1	3	1	67													.314			20
0026	30	1	24	12	68	46500	389	8	125	8000	0000			2	0	0	.46	.174	19	65	10
0027	30	1	3	1	68			00	76	0000	200	000	180	2	0	0					
0029	30	1	235	1	69	82000	300	40	125		150	000	0000		0	0	1.06	.12	17	93	16
0031	30	1	35	12	69	19500	150	45	100	0000	1100	200	1150		0	0		.177			30
0032	30	1	23	1	58		1000	00	70	2000	350	000	320	2	0	0		.37	20	80	16
0033	30	1	25	1	66	96000	180	58	107	4240			3000	1	0	0		.016			
0033	30	2	25	2	66	96000	120	3	107				3000	2	0	0					
0034	30	1	5	1	65	34500	122	70	124				300	2	0	0		.05		95	50
0035	30	1	25	1	64	25000	140	35	175		450		400	2	0	0	2.26	.13		95	12
0035	30	2	3	2	47	20000		00		0000	70	000	0000	2	0	0					
0035	30	3	3	3	47	20000		00		0000	70	000	0000	2	0	0					
0036	30	1	6	1	51	13200	450	6		60			12		3	2					
0037	30	1	6	1	50	13500	425	6						2	3		.6			99	4
0038	30	1	4	1	58	84000	500	9	71					2	0	0					
0039	30	1	5	1	70										0	0					
0041	30	1	6	1	57										3						
0042	30	1	23	1	69	50000	2000		99	4200	360	20		2	0	0					
0043	30	1	7	1	70	20000	410	4	50	9000	0000	42	20	2	0	0	2.0	.029	38.	98	9
0045	30	1	5	78	63	50000	155	14	70	418			150	2	0	0	1.24			50	26
0046	30	1	6	12	68	100000	250	13	35	0000	0000	000	0000	2	2	3	.85			99	
0046	30	2	6	34	68	100000	250	13	35	0000	0000	000	0000	2	2	3	.85			99	
0047	30	1	24	12	58	60000	500	6	90	100					0	0					
0048	30	1	6	1	65	32000	250	4	27	0000	0000	000	0000	2	2	2			18		7
0049	30	1	5	1	67			6							0	0					

CONTROL SYSTEM

FDRY NO.	CO TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER CONSUMPTION DUST	GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0050	30	1	5	1	68	27500		50							0	0	1.09	.034		97	
0051	30	1	6	12																	
0052	30	1	3	2	69	26000	450	00	86	0000	150	000	0000	2	0	0		.165			8
0052	30	2	23	4	69	24000	2200	00	98	0000	520	000	0000	2	0	0					
0054	30	1	5	1	69										0	0					
0056	30	1	4	1	69										0	0					
0058	30	1	4	1	57										0	0		.15			
0058	30	2	4	2	57										0	0		.15			
0061	30	1	4	12	69	85000	500		80	750	0000	70		2	0	0			22	81	20
0062	30	1	4	12	66	72000	500	4	85	750			40	2	0	0		.227		80	17
0063	30	1	6	12	67	52000															
0065	30	1	25	1	69	80000	185	80		3000	1600	400	1800		0	0		.047			30
0065	30	2	25	2	69	80000	185	80		3000	1600	400	1800		0	0		.035			30
0065	30	3	3	3											0	0					
0065	30	4	3	4											0	0					
0065	30	5	3	6											0	0					
0066	30	1	5	5											0	0					
0067	30	1	125	1	66	27000	600	53	120	6000		999	785	1	0	0	12.9	.079		99	45
0067	30	2	125	2	69	50000	1900	53	98	9999			2200	1	0	0	5.83				50
0067	30	3	3	3	55				98		600				0	0					
0068	30	1	3	1	64	30000	800		100	0000	600			2	0	0					
0068	30	2	23	2	64	30000	800		100		600			2	0	0					
0068	30	3	23	3	64	30000	800		95					2	0	0					
0068	30	4	23	4	64	30000	800							2	0	0					
0068	30	5	2	5	69	35000	1200							2	0	0					

CONTROL SYSTEM

FDRY	CD	CTL	SYS	FCES	YEAR	GAS	GAS	PRES	HEIGHT	AFTBURN	WATER	CONSUMPTION		NOISE	FIL	AIR/CLOTH	INLET	OUT	CATCH	COLL	MLT
NO.	TY	SYS	TYP	CONT	INST	VOLUME	TEMP	DROP	EXH STK	SIZE	DUST	GAS	RECIRC	CONTR	MED	RATIO	CONC	CONC		EFF	RTE
0069	30	1	236	5	70	35500	500	18	85		40			2	3	2	4.0	.02	15.	99	
0069	30	2	236	6	70	35600	500	18	85		60			2	3	2	4.0	.02	15.	99	
0069	30	3	35	3	69	22400	170	72	120	0000	300	23	850	2	0	0	4.0	.05	15.	99	
0069	30	4	35	4	68	26600	170	72	120	0000	300	23	850	2	0	0	4.0	.05	15.	99	
0069	30	5	35	1	68	29000	170	72	120	0000	450	30	800	2	0	0	4.0	.05	15.	99	
0069	30	6	35	2	70	29000	170	72	120	0000	350	30	1000	2	0	0	4.0	.05	15.	99	40
0070	30	1	5	1	66										0	0		.05		99	
0070	30	2	5	2	67										0	0		.05		99	
0070	30	3	5	3	67										0	0		.05		99	
0070	30	4	5	4	68										0	0		.05		99	
0071	30	1	5	1	65	027000	110	80	129	0000	1000		2700	2	0	0	6.67	.075		99	35
0071	30	2	5	2	65	027000	110	80	129	0000	1000		2700	2	0	0	8.8	.051		99	45
0071	30	3	5	3	65	027000	110	80	129	0000	1000		2700	2	0	0		.05			
0071	30	4	5	4	70	27000	110	80	150	0000	800		2500	2	0	0					
0072	30	1	3	1					81	0000	750			2	0	0					
0072	30	2	3	2					81	0000	750			2	0	0					
0072	30	3	3	3					81	0000	750			2	0	0					
0072	30	4	3	4					81	0000	750			2	0	0					
0072	30	5	3	5					81	0000	750			2	0	0					
0072	30	6	3	6					81	0000	750			2	0	0					
0072	30	7	6	10	68	110000	265	12	107	0000	0000			2	2	3					
0073	30	1	4	12	64	126000	500								0	0					
0074	30	1	3	1	57			00	50	50			200	2	0	0					
0075	30	1	6	1																	
0076	30	1	26	1	52	12500	450	6		500			3	2	3	2	.6				

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                                                   CONTROL  SYSTEM

FDRY CD CTL SYS  FCES YEAR  GAS    GAS  PRES HEIGHT  AFTBURN WATER CONSUMPTION NOISE FIL AIR/CLOTH INLET  OUT  CATCH COLL MLT
 NO. TY SYS TYP  CONT INST VOLUME TEMP  DROP EXH STK  -SIZE   DUST GAS RECIRC  CONTR MED   RATIO   CONC  CONC        EFF RTE

0077 30  1  4     12   57  84000  500                                                0       0
0077 30  2  4     34   57                                                            0       0
0080 30  1  6      1
0081 30  1  6      1   52  32000  500    6            2000                35     2    3       2
0083 30  1 23      1   57                00     60    2300               400     2    0       0
0083 30  2  4      2   57                       60    2300               400     2    0       0
0084 30  1  6      1       40000  175                 7000   0000 000   0000          2       2    4.0   .8     35    80  30
0085 30                                                                                           8.35  .154   23        24
0087 30  1  5      1   69  21100 1500   25      52    0000    420        395     2    0       0
0088 30  1  3      1   57  69000  300   25      93                                    0       0          .144            17
0088 30  2  3      2   57  69000  300   00      93                                    0       0          .144            17
0089 30  1  3      1
0090 30  1 24     12   61  96000  500    5     100    2400   0000 000   0000    2    0       0    1.98  .83   6.8    61  17
0090 30  2 24     34   61  96000  500    5     100    2400   0000 000   0000    2    0       0    1.98  .83   6.8    61  17
0091 30  1 24     12   59  84000  400    6      94    1000   0000 220   0000    2    0       0          .27          86  21
0091 30  2 24     34   60  84000  400    6      94    1000   0000 220   0000    2    0       0          .30          84  21
0091 30  3 24     56   61  84000  400    6      94    1000   0000 220   0000    2    0       0          .17          88  21
0092 30  1  4      1       60000  500                                                0       0     .97  .16          84
0093 30  1 23      1   58                       96            200       0000     2    0       0
0093 30  2 23      2   60                       96            200       0000     2    0       0
0094 30  1  5     12   67  33000  300   11      84                               2                        .7
0094 30  2  5      3   55  16600  900    6                    68 000      68     2
0095 30  1 25     12   66  36000  130   26                   500         450     2    0       0          .16                20
0096 30  1 26      1   64  16000  540    7      70    3000                       2    3                  .148                20
0097 30  1  5      1   68   7200  110   20      40    0000                       2    0       0          .110
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                                                                CONTROL  SYSTEM
FDRY CD CTL SYS  FCES YEAR    GAS  GAS  PRES HEIGHT   AFTBURN WATER CONSUMPTION NOISE FIL AIR/CLOTH INLET  OUT CATCH COLL MLT
 NO. TY SYS TYP  CONT INST VOLUME TEMP  DROP EXH STK     SIZE  DUST GAS RECIRC CONTR MED  RATIO     CONC  CONC        EFF RTE
0098 30   1  26    12   61 100000  550    7     70                                   3     2                           99  40
0099 30   1  35    12   69  19380   80   25    104      0000  190  60    250     2   0     0           .27                   11
0101 30   1  25    12   67  30000  170   40                                          0     0     1.48  .04          98
0102 30   1   5     1   67                                                           0     0
0104 30   1  26     1   60          420    4     60           0000       0000     2   3
0105 30   1   4    12   57  33000  500                                               0     0
0106 30   1   3     1   66         1800   00     65                        300     2   0     0                               9
0108 30   1   6    12   63  24000  530    6     61                         25         3     2          .243                   9
0109 30   1  45    12   66   4500 1500   21     42                         75         0     0                           80   5
0109 30   2  45    23   66   4500 1500   21     42                         75         0     0                           80   5
0109 30   3  45     4   66   4500 1500   28     42                         75         0     0                           80   5
0110 30   1   5    12   66  25000   70   25                    700         650         0     0          .153                  20
0112 30   1   3     1   52                00     68                        175         0     0
0113 30   1   1     1                     00     52      0000 0000 000   0000     2   0     0      .95
0113 30   2   1     2                     00     52      0000 0000 000   0000     2   0     0      .95
0114 30   1   3    12   69                40    125                                   0     0
0115 30   1                               00     56                        200     2   0     0
0115 30   2                               00     56                        200     2   0     0
0116 30   1  23     1       23000  800           45      3150                         0     0           .88
0116 30   2  23     2       23000  800           45      3150                         0     0           .88
0118 30   1   3    12   55         2000   00                               250         0     0
0118 30   2   3    34   63         2000   00                               250         0     0
0118 30   3   3     5   68                00                                          0     0
0119 30   1   5     2                                                                 0     0
0120 30   1   6    12                                                                 3
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CONTROL SYSTEM

FDRY NO.	CD TY	CTL SYS	SYS TYP	FCES CONT	YEAR INST	GAS VOLUME	GAS TEMP	PRES DROP	HEIGHT EXH STK	AFTBURN SIZE	WATER DUST	CONSUMPTION GAS	RECIRC	NOISE CONTR	FIL MED	AIR/CLOTH RATIO	INLET CONC	OUT CONC	CATCH	COLL EFF	MLT RTE
0121	30	1	3	1	64			00					250		0	0					
0121	30	2	3	2	64			00					250		0	0					
0122	30	1	5	1	70	16600	158	25	81		330	000	300	2	0	0		.024			8
0123	30	1	6	1	51	13000	500		20					2	3						6
0124	30	1	26	1	66		500	3						2	3						4
0125	30	1	5	12	67	33000	80	88	78	9999	750		750		0	0		.05	24	99	35
0126	30	1	5	1	70	43800	150	26	114	0000	450	350	550	2	0	0					
0127	30	1	26	1	51	10800	440	4		80				2	3	2					
0128	30	1	26	1	50	12550	450	3		2000			15	2	3						
0129	30	1	6	1	60										3						
0130	30	1	26	1	60	28000	500	6	49	3000			20	2	3					90	9
0132	30	1	25	12	68	30000	165	45	62	1200			60	2	0	0	5.0	.038		99	10
0134	30	1	5	12	67	60000		50							0	0	2.43	.068		97	
0135	30	1	5	1	69										0	0					
0136	30	1	5	12	69	30000	250	7	150	0000	150	75	0000	2	0	0					
0137	30	1	23	1	53			00	77	640			450	2	0	0					
0137	30	2	23	2	53			00	77	640			450	2	0	0					
0138	30	1	5	1	68	18600									0	0		.114			
0139	30	1	24	1	67	72000	1400	7	85						0	0		.183		83	16
0140	30	1	5	12	69	26000		35							0	0					
0141	30	1	24	12	67	60000	350	8	125	1500			30	2	0	0					
0143	30	1	7	1											0	0					
0144	30	1	5	1	69	20000		25							0	0					
0145	30	1	5	1	67	27000	867	6	50				115	2	0	0					
0146	30	1	5	12	69	40000	155	20		0000	1300	400		2	0	0	1.84	.83	20		52

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                                                   CONTROL  SYSTEM                                                        PAGE  8
FDRY CD CTL SYS  FCES YEAR  GAS    GAS  PRES HEIGHT  AFTBURN WATER CONSUMPTION  NOISE FIL AIR/CLOTH INLET  OUT  CATCH COLL  MLT
 NO. TY SYS TYP  CONT INST VOLUME  TEMP DROP EXH STK  SIZE    DUST GAS RECIRC   CONTR MED   RATIO   CONC  CONC        EFF  RTE
0150 30  1  26    12   61   48500  500    9   32              0000  10  0000      2    3     2      2.04         18    99   37
0151 30  1   5     1   70   20000 1200   50           0000                             0     0      1.09  .054         97   23
0152 30  1   5    12   70   42000        50                                            0     0      1.19  .033         97
0156 30  1   3     1
0157 30  1  26     1   62   15000  480   15           3000                  20    2    3     3
0158 30  1   3     1   65   35000  800   00   80                           600    2    0     0
0159 30  1   5     1   70   11800        25                                            0     0
0160 30  1   5    12   68   35000  150    5  120      0000                 300    2    0     0      2.16  .257   34    88   16
0161 30  1   4     1   57   18000  500                                                 0     0
0162 30  1   5     1        20000  160   16   50      0000     70   30              2    0     0      1.14  .25          78
0163 30  1   5    12   68   50700  171   30   82                                    2    0     0            .074
0165 30  1   6    12   69   34700  120       50      0000     0000 000  0000      2    2     3                   20
0166 30  1   2     1                           97                                   2    0     0            15.2   LBP   ER   HR
0167 30  1   3     1                           79                          300      2    0     0            1.43              22
0167 30  2   3     2                           79                          300      2    0     0            1.43              22
0168 30  1   5     1   69                      45      0000                 25      2    0     0
```

ANALYSIS

FDRY	CD	CTL	GAS ANALYSIS PERCENT							PARTICLE PROP. PERCENT :LESS THAN									CATCH PROP. PERCENT :LESS THAN							
NO.	TY	SYS	CO	CO2	O2	N2	H2	SO2	H2O	2	5	10	20	50	100	200	500	1000	2	5	10	20	50	100	200	500
0009	40	1								65	92	98	99													
0009	40	2								30	50	65	82	90	99											
0014	40	1								64	82	98	99													
0018	40	1	.2	9	10	77			4		2	12	34	92	99	99										
0021	40	1	2	7	12	75		4																		
0025	40	1	00	12	12	76																				
0026	40	1								13	28	45	55	60					74	90	95	98	99	99		
0032	40	1	2	4	7	86					54	86	98	99	99	99										
0035	40	1								99																
0046	40	1								99	99															
0046	40	2								99	99															
0061	40	1																	8	16	23	31	99	99		
0067	40	1	12	10	3						14	15	15	21	99								16	99		
0067	40	2	3	16	1								19	25	99											
0084	40	1	.2	10	11																					
0099	40	1	1	3	17	75	3																			
0113	40	1								64	90	97	99	99												
0113	40	2								64	90	97	99	99												
0116	40	1									5	25		53												
0116	40	2									5	25		53												
0122	40	1												82												
0125	40	1	00	14	7																					
0146	40	1	00	13	7	80	00							99	99											
0151	40	1								.6	2	3	8	99	99											
0162	40	1																					84			

```
                                                           ANALYSIS                                                PAGE   2
FDRY CD CTL         GAS ANALYSIS PERCENT            PARTICLE PROP. PERCENT :LESS THAN        CATCH PROP. PERCENT :LESS THAN
 NO. TY SYS  CO  CO2  O2  N2  H2  SO2   H2O          2  5  10 20 50 100 200 500 1000          2  5  10 20 50 100 200 500

0163 40  1    00   5   14  81

0166 40  1                                                       86

0167 40  1    00   9   12  79

0167 40  2    00   9   12  79
```

ANALYSIS AND COSTS

FDRY	CD	CTL	CHEMICAL ANALYSIS										COM	BASIC	AUX	ENG	INST	TOT	OPER	MAINT	DEPR	OVE
NO.	TY	SYS	SIO2	CAJ	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	BUS	EQUIP	EQUIP	COST	COST	COST	COST	COST		HEA
0001	50	1																150				
0002	50	1																375				
0003	50	1																8				
0004	50	1												153	21	000	7	181			14	
0005	50	1																60				
0007	50	1																420				
0008	50	1												33	000	8	8	49	10	1		
0009	50	1																384				
0009	50	2																384				
0011	50	1																358				
0012	50	1																999				
0013	50	1																44				
0015	50	1																70				
0016	50	1																45				
0016	50	2																45				
0020	50																	200				
0021	50	1												302	108			410				
0026	50	1												150	50	25	50	275	2	1	28	2
0027	50	1												60	20	5	15	100				
0028	50	1																100				
0029	50	1												284	31	85		610	63	5	50	53
0030	50																	35				
0031	50	1												80	160							
0032	50	1												26	6	2	5	39	1	3	2	1
0034	50	1																500				

```
                                                         ANALYSIS  AND  COSTS
FDRY CD CTL             CHEMICAL  ANALYSIS                             COM BASIC AUX    ENG INST  TOT OPER MAINT DEPR OVER EQUIP TOT
 NO. TY SYS  SIO2  CAJ  AL2O3  MGO  FEO,FE  MNO   PBO  ZNO   SNO  SOX  BUS EQUIP EQUIP COST COST COST COST COST      HEAD CHANG ANN
0001 50  1
                                                                                                  150
0002 50  1
                                                                                                  375
0003 50  1
                                                                                                    8
0004 50  1
                                                                            153    21  000    7  181                 14
0005 50  1
                                                                                                   60
0007 50  1
                                                                                                  420
0008 50  1
                                                                             33   000    8    8   49   10    1                 00
0009 50  1
                                                                                                  384                            50
0009 50  2
                                                                                                  384                            50
0011 50  1
                                                                                                  358
0012 50  1
                                                                                                  999
0013 50  1
                                                                                                   44
0015 50  1
                                                                                                   70
0016 50  1
                                                                                                   45
0016 50  2
                                                                                                   45
0020 50
                                                                                                  200
0021 50  1
                                                                            302   108             410
0026 50  1
                                                                            150    50   25   50  275    2    1   28    2     1  34
0027 50  1
                                                                             60    20    5   15  100
0028 50  1
                                                                                                  100
0029 50  1
                                                                            284    31   85       610   63    5   50   58    00 176
0030 50
                                                                                                   35
0031 50  1
                                                                             80   160
0032 50  1
                                                                             26     6    2    5   39    1    3    2    1    00   7
0034 50  1
                                                                                                  500
```

APPENDIX B
EXHIBIT I
SECTION 6 PAGE 1

```
                                                        ANALYSIS  AND  COSTS                                          PAGE   2
                                                                        COM BASIC AUX   ENG  INST TOT  OPER MAINT DEPR OVER EQUIP TOT
FORY CD CTL                   CHEMICAL  ANALYSIS                        BUS EQUIP EQUIP COST COST COST COST COST      HEAD CHANG ANN
 NO. TY SYS  SIO2  CAO  AL2O3   MGO  FEO,FE  MNO  PBO  ZNO    SNO  SOX
                                                                               45  56    10    10 121    12   10
0035 50  1                            95.
                                                                                4   1     1     2   8     5    4
0035 50  2
                                                                                4   1   000     2   7     5    4
0035 50  3
                                                                                                   70
0036 50  1
                                                                               16   5           3  24     1    4     1    2         8
0037 50  1
                                                                                                  120
0038 50  1
                                                                                                   31
0040 50
                                                                               18  10     1     8  37                              25
0042 50  1
                                                                                                  150                              46
0043 50  1
                                                                                                  125
0045 50  1
                                                                                                  250
0046 50  1
                                                                                                  250
0046 50  2
                                                                                                  150
0047 50  1
                                                                                                9  45          1
0048 50  1
                                                                                                                                  30
0050 50  1
                                                                               28  40     5    32 105     4    5     5   15    00  29
0052 50  1
                                                                               26   9   000    23  58     3    2     3    8    00  15
0052 50  2
                                                                                                  125
0053 50
                                                                               80  30     4    40 154     7    5     6         00
0061 50  1
                                                                                                  132
0062 50  1
                                                                                                  250
0064 50
                                                                              350
0065 50  1
                                                                              350
0065 50  2
0066 50  1    12.3                      11.1
0074 50  1                                                                                         40
```

ANALYSIS AND COSTS

FDRY NO.	CO TY	CTL SYS	SIO2	CAO	AL2O3	CHEMICAL ANALYSIS MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVER HEAD	EQUIP CHANG	TOT ANN
0076	50	1																12						
0078	50																	45						
0080	50	1																75						
0081	50	1																81						
0083	50	1																100						
0085	50		28.7			1.3	14.7		1.4				24											
0086	50																	5						
0087	50	1												45	7		53	105	5	5				
0088	50	1																75						
0090	50	1	56.3	42.									.9					325	12	15	22	7		56
0090	50	2	56.3	42.									.9					325	12	15	22	7		56
0091	50	1												45	14	000		277	16	20	14	20		70
0091	50	2												45	14	000		277	16	20	14	20		70
0091	50	3												45	14	000		277	16	20	14	20		70
0094	50	1												100			90	300	6	8				14
0094	50	2												6	3	2	5	16	3	1				4
0095	50	1																219						
0096	50	1																40						
0097	50	1												30										2
0098	50	1																450						
0101	50	1																226						
0106	50	1																21						
0108	50	1																100						
0109	50	1																60						
0110	50	1												51	58	6								

FDRY	CD	CTL			CHEMICAL ANALYSIS								COM	BASIC	AUX	ENG	INST	TOT	OPER	MAINT		OVER	EQUIP	TOT
NO.	TY	SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	BUS	EQUIP	EQUIP	COST	COST	COST	COST	COST	DEPR	HEAD	CHANG	ANN
0112	50	1																38						
0113	50	1	31.8	3.1	.05		8.6	3.7				13.9	27											
0113	50	2	31.8	3.1	.05		8.6	3.7				13.9	27											
0115	50	1																25						
0115	50	2																25						
0116	50	1	10.	3.	5.	5.	10.	10.		1.			5											
0116	50	2	10.	3.	5.	5.	10.	10.		1.			5											
0118	50	1																997						
0118	50	2																997						
0118	50	3																997						
0121	50	1																175						
0121	50	2																175						
0122	50	1												45										3
0123	50	1																35						
0124	50	1																30						
0125	50	1												72	136	27		430						
0126	50	1												120	113		23	256						
0127	50	1																40						
0128	50	1																30						
0129	50	1																23						
0130	50	1																100						
0131	50																	90						
0132	50	1												110				170						6
0136	50	1												110	45	20	35	210	6	10	6	14	00	36
0137	50	1																85						

ANALYSIS AND COSTS

			CHEMICAL ANALYSIS																					
FDRY NO.	CD TY	CTL SYS	SIO2	CAO	AL2O3	MGO	FEO,FE	MNO	PBO	ZNO	SNO	SOX	COM BUS	BASIC EQUIP	AUX EQUIP	ENG COST	INST COST	TOT COST	OPER COST	MAINT COST	DEPR	OVER HEAD	EQUIP CHANG	TOT ANN
0137	50	2																85						
0139	50	1																94						
0141	50	1																220						
0144	50	1																90						10
0145	50	1																52						
0146	50	1	20.0	1.0			33.0	1.0	5.0	38.0	2.0			80	490	100		999	30	20	99	99		380
0150	50	1	30.1	1.1	1.4	.99	11.6	5.5	20.	14.7				300	25	25		500	25	10				
0151	50	1												250				389						
0155	50																	140						
0157	50	1																40						
0158	50	1																71						
0160	50	1												45	105		50	200	24	10			00	34
0162	50	1																150						15
0163	50	1																367						20
0165	50	1												60	5	5	30	100	5	1	5	5	.5	16
0166	50	1											3.	8			5	13						14

FORMAT FOR DATA BANK

SECTION I GENERAL FOUNDRY DATA

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
LOC	Location (1st 3 Digits of Zip Code)
MET CST	Type Metal Cast (Code) 1 Gray Iron 2 Malleable Iron 3 Ductile Iron 4 Gray and Malleable 5 Gray and Ductile 6 Malleable and Ductile 7 All Three
	Percent Cast
GI	Grey Iron
MI	Malleable Iron
DI	Ductile Iron
	Ton/Mo. Melt
GI	Grey Iron
MI	Malleable Iron
DI	Ductile Iron
SIZ CLA	Size Classification (Code) 1 Under 10 2 10 - 49 3 50 - 249 4 Over 250

Abbreviation	Description
IND CLA	Industry Classification (Code) 1 Automotive 2 Agricultural 3 Cast Iron Pipe 4 Industrial and Electrical Equipment 5 Valves and Fittings, Refrigeration 6 Jobbing 7 Railroad
WT RG	Weight Range of Castings (Code) 1 Under 10 lbs 2 10 - 49 3 50 - 99 4 100 - 500 5 Over 500 6 Several of above
PRO CST	Basic Product Cast (Code) 1 Brake Drums 2 Pipe 3 Machinery and Machine Tools 4 Railroad Products 5 Automotive 6 Valves and Fittings 7 Agricultural Parts 8 Motors, Hardware, Appliances, Tools 9 Municipal items (sewer covers, grates, etc.)
NOD	Nodularization (Code) 0 None or does not apply 1 Yes

Abbreviation	Description
	Alloy Additions to the Ladle
T	Alloys Type (Code) 0 None or does not apply 1 Caloy 2 Calcium Carbide 3 Mag-Coke 4 FeSi 5 FeCr 6 Mg Fe Si 7 Inoculoy 63 8 Ce 9 Noduloy 5C
LB	Addition, lbs.
T	Alloys Type (Code) (See Above)
LB	Additions, lbs.
T	Alloys Type (Code) (See Above)
LB	Additions, lbs.
1	#1 Other Additions (Code) 0 None 1 Graphite 2 SmZ 3 Bi
LB	Additions, lbs.
2	#2 Other Additions (Code) 0 None 1 Fe Si 2 Fe Mo 3 Al 9 See Questionnaire
LB	Additions, lbs.

Abbreviation	Description
CUP REP	Cupola Replaced last 10 yrs? (Code) 0 No 1 Yes
TYP FCE	If Yes, Type of Furnace (Code) 0 Does not apply 1 Cupola 2 Channel induction 3 Coreless induction 4 Direct Arc 5 Indirect Arc 6 Air Furnace 7 Other, see Questionnaire
VENT TAP	Ventilation During Fce. Tapping (Code) 1 General 2 Local
EFF	Effectiveness (Code) 1 Excellent 2 Good 3 Fair
VENT MOLD	Ventilation During Mold Pouring (Code) 1 General 2 Local
EFF	Effectiveness (Code) 1 Excellent 2 Good 3 Fair
EERP	Foundries Visited by EERP/OLPA
ATK	Foundries Visited by A. T. Kearney & Company, Inc.

SECTION 2 FURNACE DATA

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
FCE NO.	Furnace No.
FCE TYP	Furnace Type (Code) 1 Cupola 2 Channel Induction 3 Coreless Induction 4 Direct Arc 5 Indirect Arc 6 Air Furnace 7 Other
LIN TYP	Lining Type or Coil Type (Code) 0 Does Not Apply 1 Acid 2 Basic 3 Neutral 4 Unlined 5 Single Channel Open 6 Single Channel Closed 7 Double Channel
BLT DES	Blast Description (Code) 0 Does Not Apply 1 Hot Blast >800°F 2 Warm Blast 3 Cold Blast

Abbreviation	Description
BLT HTG	Blast Heating or Frequency (Code) 0 Does Not Apply 1 No Blast Heating 2 Recuperative Heating 3 Externally Fired 4 Recup. and Ext. Fired 5 Line Frequency 6 Medium Frequency 7 High Frequency
TOP C/O	Cupola Top - Closed or Open (Code) 0 Does not Apply 1 Closed Top 2 Open Top
CHG	Top or Side Charged (Code) 0 Does Not Apply 1 Top 2 Side
GAS T-O	Gas Take-Off (Code) 0 Does Not Apply 1 Above Charging Door 2 Below Charging Door 3 Gas Take-Off into Side Draft Hood 4 Gas Take-Off into Full Roof Hood 5 Gas Take-Off into Canopy Hood 6 Gas Take-Off into Snorkel 7 Direct Shell Evacuation 8 No Gas Take-Off
AFT	Afterburners (Code) 0 Does Not Apply or None No. Indicates Use and Quantity of Burners
CHG DR	Charging Door - Open or Closed (Code) 0 Does Not Apply 1 Door Open 2 Door Closed

Abbreviation	Description
FL IN	Fuel Injection (Code) 0 Does Not Apply or Without Fuel Injection 1 With Fuel Injection
OX EN	Oxygen Enrichment (Code) 0 Does Not Apply or Without Oxygen Enrichment 1 With Oxygen
FCE USE	Furnace Use (Code) 1 Melting 2 Holding 3 Duplexing
FCE DIA	Furnace Dia., Inches
HLD CAP	Holding Cap., Tons
MLT RAT	Melt Rate, Tons/Hours
MT UT	Melting Utilization, Hour/Day
PR UT	Pouring Utilization, Hour/Day
OT UT	Other Utilization, Hour/Day
VOLUME	Blast Volume, SCFM
PRES	Blast Pressure, Oz H_2O
TEMP	Blast Temperature, °F
SIZE CH DR	Size of Charge Door, Sq. Ft.
HT DR	Height Charge Door Sill Above Floor, Ft.
CHG PRE	Charge Preheated and/or Dried (Code) 0 No or Does Not Apply 1 Preheated 2 Dried 3 Both
SIZE AFT	Afterburner Size, BUT/Hr x 10^3
AFT LOC	Afterburner Location (Code) 0 Does Not Apply 1 Above Charge Door 2 Below Charge Door 3 In Gas Take-Off 4 Above and Below Door
DIS AFT	Distance Afterburner to Gas Take-Off, Inch.
POWR SPLY	Power Supply, KW or KVA
CTL SYS	Control System No.

Appendix B
Exhibit II
Section 3, page 1

SECTION 3 MELTING OPERATION

CONTENT

Abbreviation	Description
FDRY NO.	Fourdry No.
CD TY	Card Type
	(Code)
	20 Grey Iron
	21 Malleable Iron
	22 Ductile Iron
FCE NO	Furnace No.
TOTAL MTL CH	Total Metallic Charge, lbs.
	Remelt, lbs.
	Pig Iron, lbs. (With *, Silvery Pig)
PURCH CST I	Purchased Cast Iron, lbs
PURCH STEEL	Purchased Steel, lbs.
BRIQ	Briquettes, lbs.
PUN/TURN	Punchings and/or Turnings, lbs.
LIM STN	Limestone, lbs.
	Dolomite, lbs.
	Soda Ash, lbs.
FLOU SPAR	Flourspar, lbs.
	Other, lbs.
	Carbo-Coke, Lbs.
FE-SIL	Ferrosilican, lbs.
MN	Manganese, FeMn, SiMn. lbs.
T	Additive, Type
	(Code)
	0 None
	1 Copper
	2 Silvery Iron
	3 Silicon
	4 Calcium Carbide
	5 Silicon Carbide
	6 Carnell (C_aF_2)
	7 Ferrophosphorous
	8 Graphite
LB	Additive, lbs.
ME/CO RATIO	Metal to Coke Ratio
SUL CON	Sulphur Content of Coke, %
D A	Desulphurizing Agents
	(Code)
	0 Does Not Apply or None
	1 Caustic Soda NaOH
	2 Soda Ash Na_2CO_3
	3 Calcium Carbide

Abbreviation	Description
Q S	Quality of Scrap (Code) 0 Does Not Apply 1 Rusty 2 Dirty 3 Oily 4 Clean
C M	Charging Method (Code) 0 Does Not Apply 1 Skip Hoist Side Discharge Bucket 2 Skip Hoist Bottom Discharge Bucket 3 Crane Type Charger 4 Belt Conveyor 5 Vibrating Feeder 6 Magnet 7 Manual
S P	Scrap Preparation (Code) 0 Does Not Apply or None 1 Shot Blast 2 Degreasing 3 Cut to Size
TIME	Average Length of "Light-Up", Min. Per Day
METH	Method of light-up (Code) 0 Does Not Apply 1 Wood 2 Gas 3 Oil 4 Electric 5 Other 6 More than one of above
CO	Carbon Monoxide, %
CO_2	Carbon Dioxide, %
N_2	Nitrogen, %

SECTION 4 CONTROL SYSTEM

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
CTL SYS	Control System No.
SYS TYP	Control System Type (Code) 0 No Control System 1 Fly Ash and Spark Arrester 2 Afterburner 3 Wet Cap 4 Mechanical Collector 5 Wet Scrubber 6 Fabric Filter 7 Electrostatic Precipitator
FCES CONT	Furnaces Controlled
YEAR INST	Year Installed
GAS VOLUME	Rated Gas Volume at Exh. Inlet, CFM
GAS TEMP	Gas Temperature at Exh. Inlet, °F
PRES DROP	Pressure Drop, in H_2O
HEIGHT EXH STK	Height Exhaust Stack, Ft.
AFTBURN SIZE	Afterburner Size, BTU.Hr. x 10^3
DUST	Water Consumption, Dust Collector, GPM
GAS	Water Consumption, Gas Cooling, GPM
RECIRC	Water Consumption, Recirculated, GPM
NOISE CONTR	Noise Control (Code) 1 Yes 2 No
FIL MED	Filter Media (Code) 0 Does Not Apply 1 Natural Fibre 2 Synthetic Fibre 3 Glass Fibre
	Air to Cloth Ratio
INLET CONC	Inlet Concentration, GR/SCF
OUT CONC	Outlet Concentration, GR/SCF
	Catch, lb. Dust/Ton Melt
COLL EFF	Collection Efficiency, %
MLT RTE	Melt Rate at Which Test was Made, TPH

Appendix B
Exhibit II
Section 5

SECTION 5 ANALYSIS

CONTENT

Abbreviation	Description
FDRY NO.	Foundry No.
CD TY	Card Type
CTL SYS	Control System No.
	Gas Analysis % CO
	Gas Analysis % CO_2
	Gas Analysis % O_2
	Gas Analysis % N_2
	Gas Analysis % H_2
	Gas Analysis % SO_2
	Gas Analysis % H_2O
	Particle Prop. %
	Less Than 2 Microns
	Less Than 5 Microns
	Less Than 10 Microns
	Less Than 20 Microns
	Less Than 50 Microns
	Less Than 100 Microns
	Less Than 200 Microns
	Less Than 500 Microns
	Less Than 1,000 Microns
	Catch Prop., %
	Less Than 2 Microns
	Less Than 5 Microns
	Less Than 10 Microns
	Less Than 20 Microns
	Less Than 50 Microns
	Less Than 100 Microns
	Less Than 200 Microns
	Less Than 500 Microns

Appendix B
Exhibit II
Section 6

SECTION 6 ANALYSIS AND COSTS

CONTENT

Abbreviation	Description	
FDRY NO.	Foundry No.	
CD TY	Card Type	
CTL SYS	Control System No.	
	Chemical Analysis	
	SiO_2	
	CaO	
	Al_2O_3	
	MgO	
	FeO, Fe_2O_3, Fe	
	MnO, Mn_3O_4	
	PbO	
	ZnO	
	SnO	
	SO_x	
COMBUS	Combustibles	
BASIC EQUIP	Basic Equipment Costs	\$ x 10^3
AUX EQUIP	Aux. Equipment Costs	\$ x 10^3
ENG COST	Engineering Costs	\$ x 10^3
INST COST	Installation Costs	\$ x 10^3
TOT COST	Total Cost	\$ x 10^3
OPER COST	Operating Cost	\$ x 10^3
MAINT COST	Maintenance Cost	\$ x 10^3
DEPR	Depreciation	\$ x 10^3
	Overhead	\$ x 10^3
EQUIP CHANG	Process and Equipment Changes	\$ x 10^3
TOT ANN	Total Annual Costs	\$ x 10^3

MATERIAL AND HEAT BALANCE

Appendix C consists of three exhibits, each of which deals with material and heat balances of foundry melting furnaces. The first exhibit of this appendix is the Cupola Material and Heat Balance Model. This exhibit discusses the development of the mathematical model and the nature of input required. A sample of the material balance and heat balance outputs and the chemical reactions considered in the model are given.

Exhibit 2 of this appendix is a listing of the FORTRAN IV computer program version of the material and heat balance.

The final exhibit of Appendix C is a series of material and heat balances for cupolas and electric furnaces. A material and heat balance is given for different furnace classifications. Each classification, as discussed earlier in this report, represents a unique furnace type and operating characteristics found in practice.

CUPOLA MATERIAL AND HEAT BALANCE MODEL

Because the major single source of air emissions from the foundry is the cupola, a material and heat balance model has been developed to compute (for given operating conditions) the estimated emissions generated by the cupola.

The model requires the following general inputs:

1. Size and certain design characteristics of the cupola.
2. The type and hourly melting rate of iron being produced.
3. The makeup of the charge, including metallics, fuel, flux and additives.
4. The rate and temperature of the blast air including any oxygen enrichment.
5. The temperature of the top gases immediately above the burden.

Using these inputs, the computerized version of the model will calculate a material and heat balance for the cupola and print out a summary report showing these results. An example of the output report is shown in a later section of this appendix.

The approach taken in constructing the model has been to concentrate on those aspects of cupola design and operation which will influence the emissions characteristics of the top gases. Those aspects which relate to such matters as detailed metallurgical characteristics of the tapped iron but do not influence emissions have not been included in the model.

A search of the literature and previous research was undertaken to collect the known physical and chemical relationships in the cupola that influence emissions characteristics in terms of composition and quantity.

Most of the relationships included in the model are based on known chemical and physical laws and their accuracy with regard to the computed results is limited only by the accuracy of the input data. It has been necessary, however, to include in the model several empirical relationships cited in the literature to permit the calculation of estimated quantities in the top gases of particulate matter and sulfur dioxide. Furthermore, in order to simplify the task of specifying the input values and to limit the required data to figures commonly available in foundry operation, the average or typical composition of charge materials has been incorporated into the model. For example, when specifying for the model that the tapped iron is gray iron, the model uses an average composition for gray iron in its calculations. This has been done to avoid having to specify the actual chemical composition of charging materials and tapped iron in order to use the model. In practice, the slight variations in the actual composition of materials from the averages used in the model will have very little effect on the results calculated by the model as far as emissions are concerned.

The average compositions for materials used in the model have been taken from the literature and are shown in the following table. It will be noted that the chemical compositions used are not rigorously complete and only those components which can significantly affect the calculated emissions are included.

The balance of the documentation of the model included in the report consists of a description of the chemical and physical relationships incorporated in the model. A listing of the FORTRAN IV computer program version of the model is given in Exhibit 2 of this appendix.

Average Composition of Materials Used in the Cupola Model
(Figures Given Are Weight Percentages)

A. Metallics

	C	Si	Mn	S
Gray Iron	3.2%	2.0%	0.6%	0.12%
Malleable Iron	2.5	1.2	0.6	0.12
Ductile Iron	3.8	2.4	0.6	.03
Pig Iron	3.5	0.6	1.5	.05
Silvery Pig	2.5	10.0	0.7	.05
Iron Scrap	3.3	2.1	0.6	.12
Steel Scrap	0.4	0.2	0.6	.05
Ferrosilicon	0.05	50.0	0.0	0.00

B. Fluxes

	SiO_2	(Ca, Mg)O	CaF_2	CaC_2	Na_2O	CO_2 (asCO_3)	Al_2O_3
Limestone & Dolomite	1.0%	54.0%	-	-	-	45.0%	-
Fluorspar	2.0	8.0	84.0	-	-	6.0	-
Fdry Carbide	3.0	14.0	-	70.0	-	11.0	2.0
Soda Ash	-	-	-	-	57.0	43.0	-

C. Foundry Coke Ash

SiO_2	Al_2O_3	Fe_2O_3	(Ca, Mg)O	Misc.(1)
50.0%	35.0%	8.0%	3.0%	4.0%

D. Cupola Refractory Linings

	SiO_2	Al_2O_3	MgO	Misc(1)
Acid	60.0%	30.0%	-	10.0%
Basic	20.0	20.0	60.0	-

Note: (1) Miscellaneous category includes various other metallic oxides and trace elements not listed.

SPECIFIC INPUTS REQUIRED FOR THE MODEL

Nature of Cupola and Metal Produced

1. Diameter of the cupola in inches
2. Type of lining
    a. Acid
    b. Basic
    c. None (water cooled)
3. Type of iron being produced
    a. Gray
    b. Malleable
    c. Ductile
4. Rate of molten iron produced in tons per hour
5. Temperature of the tapped iron in degrees Fahrenheit

Characteristics of Charge

1. Metallics (fraction or relative weight of each)
    a. Pig iron
    b. Silvery pig
    c. Scrap
        1) Steel
        2) Iron
    d. Foundry returns
        1) Gray
        2) Malleable
        3) Ductile
    e. Ferrosilicon (50%)

2. Fuel
    a. Metal to coke ratio
    b. Coke analysis
        1) Fixed carbon (fraction)
        2) Ash content (percent)
        3) Sulfur content (percent)
    c. Other fuels (if any)
        1) Natural gas (SCFM)
        2) Fuel oil (gallons/min.)
3. Flux (percent to metal of each)
    a. Limestone and/or dolomite
    b. Flourspar
    c. Foundry carbide
    d, Soda ash

Characteristics of the Blast

1. Air
    a. Quantity of air (SCFM)
    b. Inlet air temperature (^{o}F)
    c. Relative humidity of air (fraction)
2. Oxygen enrichment (SCFM)
3. Blast temperature (^{o}F)

Characteristics of Exhaust Gases

1. Top gas temperature (top of burden-^{o}F)
2. Stack gas above charge door
    a. Volume of stack gas (CFM)
    b. Temperature of stackgas for volume given (^{o}F)
    c. Carbon monoxide in stack gas (%/vol.)

CHEMICAL REACTIONS CONSIDERED IN THE MODEL

Oxidation Zone

1. C (coke) + O_2 -> CO_2
2. CH_4 (natural gas) + $2 \cdot O_2$ -> $CO_2 + 2 \cdot H_2O$
3. $4 \cdot C_5H_{11}$ (fuel oil*) + $31 \cdot O_2$ -> $20 \cdot CO_2 + 22 \cdot H_2O$

   *The composition shown for fuel oil represents the average total ratio of carbon to hydrogen for the sum of the many hydrocarbon compounds which comprise a typical fuel oil used in cupola operations.
4. $Si + O_2$ -> SiO_2
5. $2 \cdot (Fe, Mn) + O_2$ -> $2 \cdot (Fe, Mn)O$
6. $2 \cdot CaC_2$ (foundry carbide) + $5 \cdot O_2$ -> $2 \cdot CaO + 4 \cdot CO_2$

Reduction Zone

7. C (coke) + CO_2 -> $2 \cdot CO$
8. C (coke) + H_2O -> $CO + H_2$

Preheating Zone

9. $(Ca, Mg)CO_3$ -> $(Ca, Mg)O + CO_2$
10. Na_2CO_3 -> $Na_2O + CO_2$
11. $S + Fe$ -> FeS

Slagging Reactions

12. $(Ca, Mg, Fe, Mn)O + SiO_2$ -> $(Ca, Mg, Fe, Mn)SiO_3$
13. $CaO + FeS$ -> $CaS + FeO$
14. $CaS + FeSiO_3 + 2 \cdot MnO$ -> $CaSiO_3 + Fe + 2 \cdot Mn + SO_2$

MATERIAL BALANCE RELATIONSHIPS CONSIDERED IN THE MODEL

The material balance relationships employed in the model use the input quantities (specified on the preceding pages) of materials and the average compositions of materials shown earlier in this exhibit. The source of empirical relationships used are shown for reference. The quantities are all computed to a base of 2,000 pounds of tapped iron.

1. Silicon Oxidized = Net Silicon Loss from Metalics

   Net Silicon Loss From Metalics = Weight of Silicon in Metalic Charge - Weight of Silicon in Tapped Iron

2. Manganese Oxidized (same approach as for silicon above)
3. Carbon From Coke Into Iron = Net Carbon Gain of Tapped Iron

   Net Carbon Gain = Weight of Carbon in Tapped Iron - Weight of Carbon in Charged Metalics

4. Oxygen Input = Weight of Oxygen in Blast Air + Oxygen Enrichment
5. Water Input = Water Content of Blast Air as a Function of Temperature and Relative Humidity
6. Oxygen Available For Fuel Combustion = Oxygen Input - Oxygen Used to Oxidize Silicon, Manganese and Foundry Carbide
7. Oxygen Available to Burn Coke = Oxygen Available For Fuel Combustion - Oxygen Consumed to Burn Natural Gas and/or Fuel Oil

8. Coke Consumed in Complete Burning

   = Carbon Required to Combine with Available Oxygen /Carbon Content of Coke

9. Total Water to React With Coke

   = Water Input in Air + Water Generated in Combustion of Natural Gas and Fuel Oil

10. Coke Available to Reduce Carbon Dioxide

   = Total Coke Input - Coke Consumed in Complete Burning

   - Coke Required to Reduce Total Water

11. Resulting Carbon Dioxide

   = CO_2 from Complete Combustion of Coke

   - CO_2 Reduced by Remaining Coke

   + CO_2 from Calcining of Carbonates

12. Resulting Carbon Monoxide

   = CO from Water Reduction + CO from CO_2 Reduction

13. Resulting Hydrogen = Weight of Hydrogen in Total Water

14. Silica From Cupola Lining = Weight of Lining Melted as a function of Cupola Diameter*

   x Silica Content of Lining

15. Magnesium Oxide From Cupola Lining (same approach as for silica)

16. Total Silica For Slag = Silica From Coke Ash + Silica Fluxes + Silica From Cupola Lining

17. Total Calcium and Magnesium Oxide for Slag

   = (Ca, Mg)O from Fluxes, Cupola Lining, and Coke Ash

18. Slag Basicity Ratio = Total (Ca, Mg)O/SiO_2

*The Cupola and Its Operation (third edition; Des Plaines, Illinois: American Foundrymen's Society, 1965), p. 233.

19. Sulfur in Slag = Function of the Basicity Ratio* of the Slag

20. Sulfur To Top Gas (SO_2) = Total Sulfur Input in Coke and Metalics - Sulfur Output in Tapped Iron - Sulfur Output in the Slag

21. Oxidation of Iron To Slag = Assumption that Slag Contains Two Percent FeO Derived from Oxidation of Iron*

*Note: No method could be found in the literature to predict the amount of iron oxidized and going into the slag. Typical compositions suggest that two percent is a good average value.

22. Particulate Matter in Top Gases = Empirical Function**of:
    a) Blast Volume
    b) Coke Ratio
    c) Melting Rate

23. Total Slag Output = Weight of Slag Forming Constituents in Coke Ash and Fluxes
    + SiO_2, MnO, and FeO from Metalics
    + Cupola Lining Melted
    - Emissions Dust

24. Total Metallic Inputs = Tapped Iron Weight
    + Si, Mn, Fe Loss From Metallic Charge
    - C and S Gain in Tapped Iron

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*The Cupola and Its Operation, p. 236

**Engels and Weber, Cupola Emission Control, trans. (Cleveland, Ohio: Gray and Durtile Iron Founders' Society, 1969, Original, 1967), pp. 52-54.

HEAT BALANCE RELATIONSHIPS CONSIDERED IN THE MODEL

The heat balance relationships are calculated in B.T.U.'s per hour of cupola operation.

Heat Inputs

1. Potential Heat of Fuels = Heat of Total Combustion for Weight of Carbon in Coke plus Natural Gas and Fuel Oil Combustion.
2. Heat of Oxidation of Metallics = Heats of Oxidation for Weight of Iron, Silicon, Manganese, and Carbide Oxidized per Hour
3. Sensible Heat of Air Blast = Temperature x Specific Heat x Weight of Air Blast Per Hour

Heat Outputs

1. Heat Content of Tapped Iron = Temperature x Specific Heat x Weight of Molten Iron Tapped Per Hour
2. Heat for Calcining Carbonates = Heat of Reaction for Calcining x Weight of Carbonate Fluxes Per Hour
3. Heat of Slagging = Heat of Reaction of Calcium and Magnesium Oxides with Silica To Form Silicates in the Slag

4. Heat Content of Slag = Temperature x Specific Heat x Weight of Slag - Heat of Slagging Reactions

5. Heat of Water Decomposition = Heat of Reaction with Carbon to Reduce Water to Hydrogen and Carbon Monoxide

6. Sensible Heat of Top Gas = Temperature x Specific Heat x Weight of Top Gases

7. Latent Heat of Top Gas = Potential Heat of Combustion of Carbon Monixide x Weight of Carbon Monoxide in the Top Gas Per Hour

8. Heat Radiation From the Cupola = Sum of Heat Inputs - Sum of Heat Outputs (above)

SAMPLE OUTPUT
MATERIAL BALANCE

INPUTS

	POUNDS	PERCENT
METAL CHARGE	2015	51.50
PIG IRON	288.	7.36
RETURNS	959.	24.52
STEEL SCRAP	672.	17.17
IRON SCRAP	0.	0.00
FERROALLOYS	96.	2.45
COKE	208.	5.33
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	27.	0.68
AIR	1641.	41.95
OXYGEN	0.	0.01
CUPOLA LINING	20.	0.52
TOTAL INPUT MTLS	3912.	100.00

OUTPUTS

MOLTEN IRON	2000.	51.13
SLAG	64.	1.62
EMISSIONS DUST	16.	0.40
TOP GASES	1833.	46.85
NITROGEN	1254.	68.41
CARBON DIOXIDE	375.	20.44
CARBON MONOXIDE	201.	10.99
HYDROGEN	1.	0.07
SULFUR DIOXIDE	2.	0.09

SAMPLE OUTPUT
HEAT BALANCE

```
INPUT HEAT                  B.T.U.'s
                            (000/HR.)        PERCENT

POTENTIAL HEAT
    OF FUEL                  56208.            91.51

SENSIBLE HEAT
    OF THE BLAST              2554.             4.16

HEAT FROM OXIDATION
    OF MN, FE, SI             2664.             4.34

    TOTAL INPUT HEAT         61426.           100.00

OUTPUT HEAT

HEATING AND MELTING
    OF IRON                  24212.            39.42

HEAT CONTENT
    OF THE SLAG               1085.             1.77

CALCINING OF
    LIMESTONE                  419.             0.68

DECOMPOSITION
    OF WATER                   713.             1.16

TOP GASES
    -SENSIBLE HEAT            8112.            13.21
    -LATENT HEAT             19168.            31.20

HEAT RADIATION FROM
    THE CUPOLA                7717.            12.56

VOLUME OF TOP GAS (MCF)
ACTUAL      1280.
STANDARD     508.
STOP
```

MATERIAL AND HEAT BALANCE

```
5 REAL I,I1,I2,I3,I4,I5,I6,I7,I8,I9,J,M1,M2,M3,M4,M5,M8
6 REAL K,K1,K2,K3,K4,K5,K6,K7,K8,K9,L1,L2,L3,L4,L5,N2,N3
   15 READ (1,16)D,L1,L2,I7,I8,I9
   16 16 FORMAT (10F10.0)
   20 READ (1,16)M1,T4,I1,I2,R3,I3,I
   25 READ (1,16)I4,I5,I6,K1,K2,K7,K8,G1,G2
   30 READ (1,16)F1,F2,F3,F4,A1,T1,H3,O2,T2,T3
32 READ (1,16) V3,T5,COP
   35 J=I1+I2+I3+I4+I5+I6+I+R3
   40 I1=I1/J
   45 I2=I2/J
   50 I3=I3/J
   55 I4=I4/J
   60 I5=I5/J
   65 I6=I6/J
   70 I=I/J
   75 R3=R3/J
   80 S9=(.006*I1+.1*I2+.002*I3+.49*R3+.021*I+.02*I4+.012*I5+.024*I6)
   85 S9=M1*2000.0*S9
   90 S9=S9-2000.0*M1*(.02*I7+.012*I8+.024*I9)
   92 IF (S9.LT.2.*M1) S9=2.0*M1
   95 C8=.032*I7+.025*I8+.038*I9
  100 C8=(C8-.035*I1-.025*I2-.004*I3-.033*I-.032*I4-.025*I5-.038*I6)
  105 C8=2000.0*M1*C8
  110 M8=2000.0*M1*(.009*I1+.002*(1.0-I1))
  115 O1=(.209*A1+O2)*.0847*60.0
  120 O3=O1-20.0*M1*.86*F3-1.14S9-.41*M8
  125 H4=8.631*EXP(.03598*T1)*H3*.0763*A1*60.0/7000.0
  130 K3=(O3-(10.03*G1)-1450.0*G2)/(2.66*K2)
  135 C2=1.38*O3
  140 H1=5.72*G1+519.0*G2+H4
  145 K4=.667*H1/K2
  150 H=.111*H1
  155 K5=2000.0*M1/K1
  160 K6=K5-K3-K4-C8/K2
  165 C3=4.66*K6*K2
  170 C2=C2-3.66*K6*K2
  175 C1=1.55*H1
  180 C4=100.0*C2/(C3+C2)
  185 C5=20.0*M1*(.45*F1+.06*F2+1.06*F3+.43*F4)
  190 C2=C2+C5
  195 C1=C1+C3
  200 N2=3.52*A1
  205 L4=(M1*20.0*465.0/(D/2.0)**1.75)*(L1+L2)
  210 S5=.5*K5*K7/100.+L4*(.6*L1+.2*L2)+20.0*M1*(.01*F1+.02*F2+.03*F3)
  211 S5=S5+2.14*S9
  215 M5=.0003*K7*K5+L4*(.6*L2)+20.0*M1*(.54*F1+.08*F2+.75*F3)
  220 B1=M5/S5
  225 S1=K8*K5/100.0+.0076*G1+1.34*G2
  230 S2=2000.0*M1*(.0005*(I1+I2+I3+I6)+.0012*(I4+I5+I))
  235 S2=S2-2000.0*M1*(.0012*(I7+I8)+.0003*I9)
  240 S8=L4+K7*K5/100.0
  245 S8=S8+20.0*M1*(.55*F1+.94*F2+.8*F3+.57*F4)+2.14*S9+1.29*M8
  250 S8=1.02*S8
  255 S3=(.0000659*(B1*100.0)**2.65)*S8/10000.0
  260 S8=S8+S3
```

MATERIAL AND HEAT BALANCE

```
265 S4=2.0*(S1+S2-S3)
270 R1=.02*S8*.78
275 M2=M1*2005.0-C8+S9+M8+R1+S2
280 B3=(A1+O2+G1)/((D/24.0)**2*3.1416)
285 D3=.0625*(4.0+(B3/32.8-7.0))
290 D4=280.0/K1-16.0
295 D5=56.0-29.2*M1/((D/24.0)**2*3.14)
300 V1=(N2/28.0+C2/44.0+C1/28.0+H/2.0+S4/64.0)*.01073*(T3+460.0)/14.7
305 V2=520.0*V1/(T3+460.0)
310 D6=D3*V2/M1
315 D7=.5*D6+.25*D4+.25*D5
320 S8=S8-D7*M1
325 Q1=14.45*((K5-K4)*K2-C8)+60.0*G1+8470.0*G2
330 Q2=127.4*F3*M1+2.05*R1+13.1*S9+3.02*M8
335 Q3=(T2-60.0)*(.249*N2+.224*O1+.453*H4)/1000.0
340 M3=M2/M1
345 F5=(F1+F2+F3+F4)*M2/M1/100.0
350 A5=(N2*1.3+H4)/M1
355 O6=O2*5.08/M1
360 K=K5/M1
365 G4=2.54*G1/M1
370 G5=446.0*G2/M1
375 L5=L4/M1
380 W1=M3+F5+A5+O6+K+G4+G5+L5
385 M4=2000
390 S6=S8/M1
395 N3=N2/M1
400 C6=C2/M1
405 C7=C1/M1
410 H7=H/M1
415 S7=S4/M1
420 W2=N3+C6+C7+H7+S7
425 W6=W2/100.0
430 W3=2000.0+S6+D7+W2
435 W4=W1-W3
440 S6=S6+W4
445 W1=W1/100.0
450 R5=(I4+I5+I6)*M3
455 R6=(I2+R3)*M3
460 Q4=(T4-60.0)*.2086*2.0*M1
465 Q5=2.16*.750*(C5-20.0*M1*F3*.95)
470 CS=S5*(1.-DIM(1.,(61.*M5/52./S5)))
472 Q6=.82*M5-.44*CS
475 Q7=(T4-60.0)*.321*S6*M1/1000.0
480 Q7=Q7-Q6
485 Q8=2.898*H1
490 Q9=(T3-60.0)*(.254*N2+.243*C2+.256*C1+3.466*H+.226*D7*M1)/1000.0
495 P1=4.346*C1
500 Q=Q1+Q2+Q3
505 P2=Q-Q4-Q5-Q7-Q8-Q9-P1
510 Z=Q/100.0
700 RM32=M3/W1
705 RI11=I1*M3
710 RI12=RI11/W1
715 R52=R5/W1
720 RI31=I3*M3
```

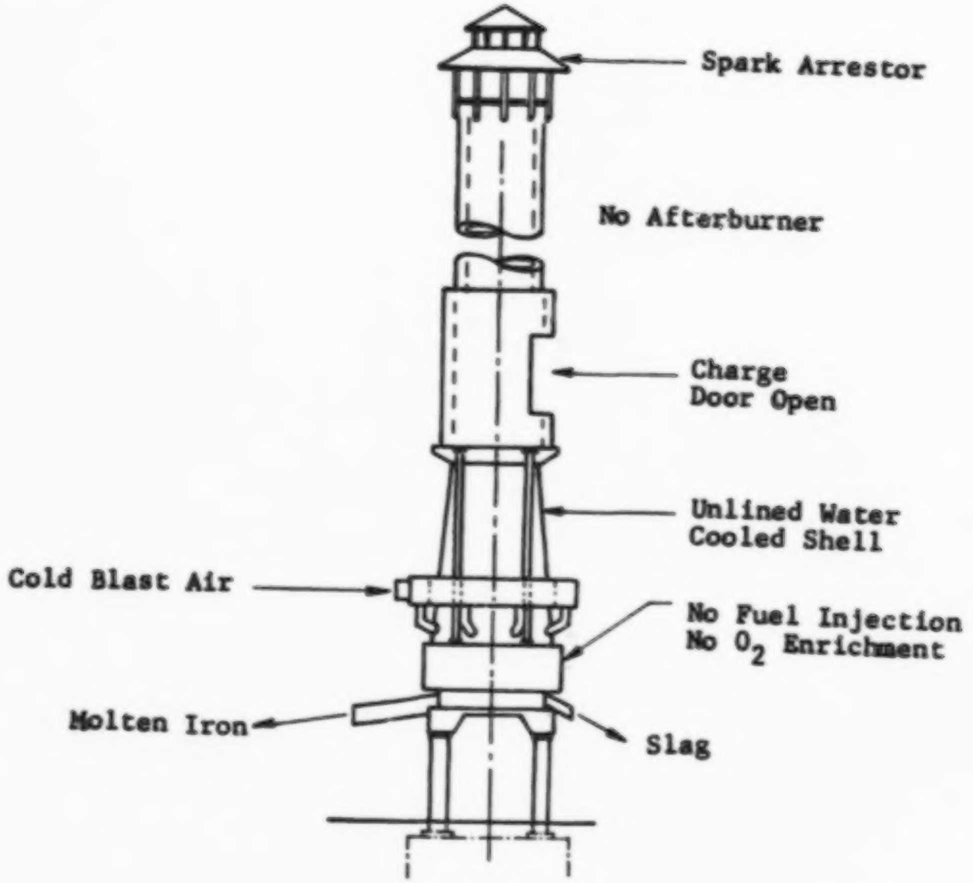
MATERIAL AND HEAT BALANCE

```
  725 RI32=RI31/W1
  730 RI01=I*M3
  735 RI02=RI01/W1
  740 R62=R6/W1
  745 RK02=K/W1
  750 G42=G4/W1
  755 G52=G5/W1
  760 F52=F5/W1
  765 A52=A5/W1
  770 O62=O6/W1
  775 RL52=L5/W1
  780 W11=100.*W1
  785 W12=W11/W1
  790 RM42=M4/W1
  795 S62=S6/W1
  800 D72=D7/W1
  805 W22=W2/W1
  810 RN32=N3/W6
  815 C62=C6/W6
  820 C72=C7/W6
  825 H72=H7/W6
  830 S72=S7/W6
  835 Q12=Q1/Z
  840 Q32=Q3/Z
  845 Q22=Q2/Z
  850 Q02=Q/Z
  855 Q42=Q4/Z
  860 Q72=Q7/Z
  865 Q52=Q5/Z
  870 Q82=Q8/Z
  875 Q92=Q9/Z
  880 P12=P1/Z
  885 P22=P2/Z
  890 WRITE (9,30)
  895 30 FORMAT (5X16HMATERIAL BALANCE//6HINPUTS/20X17HPOUNDS     PERCENT
  900 WRITE (9,40)M3,RM32
  905 40 FORMAT (12HMETAL CHARGE8X,F7.0,F9.2)
  910 WRITE (9,50)RI11,RI12
  915 50 FORMAT (8HPIG IRON12X,F7.0,F9.2)
  920 WRITE (9,60)R5,R52
  925 60 FORMAT (7HRETURNS13X,F7.0,F9.2)
  930 WRITE (9,70)RI31,RI32
  935 70 FORMAT (11HSTEEL SCRAP9X,F7.0,F9.2)
  940 WRITE (9,80)RI01,RI02
  945 80 FORMAT (10HIRON SCRAP10X,F7.0,F9.2)
  950 WRITE (9,90)R6,R62
  955 90 FORMAT (11HFERROALLOYS9X,F7.0,F9.2)
  960 WRITE (9,100)K,RK02
  965 100 FORMAT (/4HCOKE16X,F7.0,F9.2)
  970 WRITE (9,110)G4,G42
  975 110 FORMAT (11HNATURAL GAS9X,F7.0,F9.2)
  980 WRITE (9,120)G5,G52
  985 120 FORMAT (8HFUEL OIL12X,F7.0,F9.2)
  990 WRITE (9,130)F5,F52
  995 130 FORMAT (/18HFLUX AND ADDITIVES2X,F7.0,F9.2)
 1000 WRITE (9,140)A5,A52
```

MATERIAL AND HEAT BALANCE

```
1005 140 FORMAT (/3HAIR17X,F7.0,F9.2)
1010 WRITE (9,150)O6,O62
1015 150 FORMAT (6HOXYGEN14X,F7.0,F9.2)
1020 WRITE (9,160)L5,RL52
1025 160 FORMAT (/13HCUPOLA LINING7X,F7.0,F9.2)
1030 WRITE (9,170)W11,W12
1035 170 FORMAT (/16HTOTAL INPUT MTLS4X,F7.0,F9.2)
1040 WRITE (9,180)M4,RM42
1045 180 FORMAT (//7HOUTPUTS//11HMOLTEN IRON9X,F7.0,F9.2)
1050 WRITE (9,190)S6,S62
1055 190 FORMAT (/4HSLAG16X,F7.0,F9.2)
1060 WRITE (9,200)D7,D72
1065 200 FORMAT (/14HEMISSIONS DUST6X,F7.0,F9.2)
1070 WRITE (9,210)W2,W22
1075 210 FORMAT (/9HTOP GASES11X,F7.0,F9.2)
1080 WRITE (9,220)N3,RN32
1085 220 FORMAT (8HNITROGEN12X,F7.0,F9.2)
1090 WRITE (9,230)C6,C62
1095 230 FORMAT (14HCARBON DIOXIDE6X,F7.0,F9.2)
1100 WRITE (9,240)C7,C72
1105 240 FORMAT (15HCARBON MONOXIDE5X,F7.0,F9.2)
1110 WRITE (9,250)H7,H72
1115 250 FORMAT (8HHYDROGEN12X,F7.0,F9.2)
1120 WRITE (9,260)S7,S72
1125 260 FORMAT (14HSULFUR DIOXIDE6X,F7.0,F9.2)
1130 WRITE (9,265)
1135 265 FORMAT (///5X12HHEAT BALANCE//10HINPUT HEAT10X7HB.T.U.S)
1140 WRITE (9,270)
1145 270 FORMAT (20X20H(000/HR.)    PERCENT)
1150 WRITE (9,280)Q1,Q12
1155 280 FORMAT (/14HPOTENTIAL HEAT/10H   OF FUEL10X,F7.0,F9.2)
1160 WRITE (9,290)Q3,Q32
1165 290 FORMAT (/13HSENSIBLE HEAT/15H   OF THE BLAST5X,F7.0,F9.2)
1170 WRITE (9,300)Q2,Q22
1175 300 FORMAT (/19HHEAT FROM OXIDATION/16H   OF MN, FE, SI4X,F7.0,F9.
1180 WRITE (9,310)Q,Q02
1185 310 FORMAT (/19H   TOTAL INPUT HEATX,F7.0,F9.2)
1190 WRITE (9,320)
1195 320 FORMAT (//11HOUTPUT HEAT)
1200 WRITE (9,330)Q4,Q42
1205 330 FORMAT (/19HHEATING AND MELTING/10H   OF IRON10X,F7.0,F9.2)
1210 WRITE (9,340)Q7,Q72
1215 340 FORMAT (/12HHEAT CONTENT/14H   OF THE SLAG6X,F7.0,F9.2)
1220 WRITE (9,350)Q5,Q52
1225 360 FORMAT (/13HDECOMPOSITION/11H   OF WATER9X,F7.0,F9.2)
1230 WRITE (9,360)Q8,Q82
1235 350 FORMAT (/12HCALCINING OF/12H   LIMESTONE8X,F7.0,F9.2)
1240 WRITE (9,370)Q9,Q92
1245 370 FORMAT (/9HTOP GASES/16H  -SENSIBLE HEAT4X,F7.0,F9.2)
1250 WRITE (9,380)P1,P12
1255 380 FORMAT (14H  -LATENT HEAT6X,F7.0,F9.2)
1260 WRITE (9,390)P2,P22
1265 390 FORMAT (/19HHEAT RADIATION FROM/13H   THE CUPOLA7X,F7.0,F9.2)
1270 WRITE (9,400)V1,V2
1275 400 FORMAT (//23HVOLUME OF TOP GAS (MCF)/6HACTUAL4X,F7.0/
1280 + 8HSTANDARD2X,F7.0)
1960    Stop
1970    End
```

APPENDIX C
EXHIBIT 3
PAGE 1


Spark Arrestor
No Afterburner
Charge Door Open
Unlined Water Cooled Shell
Cold Blast Air
No Fuel Injection No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 1

Insufficient Data for
Heat and Material
Balance Calculations

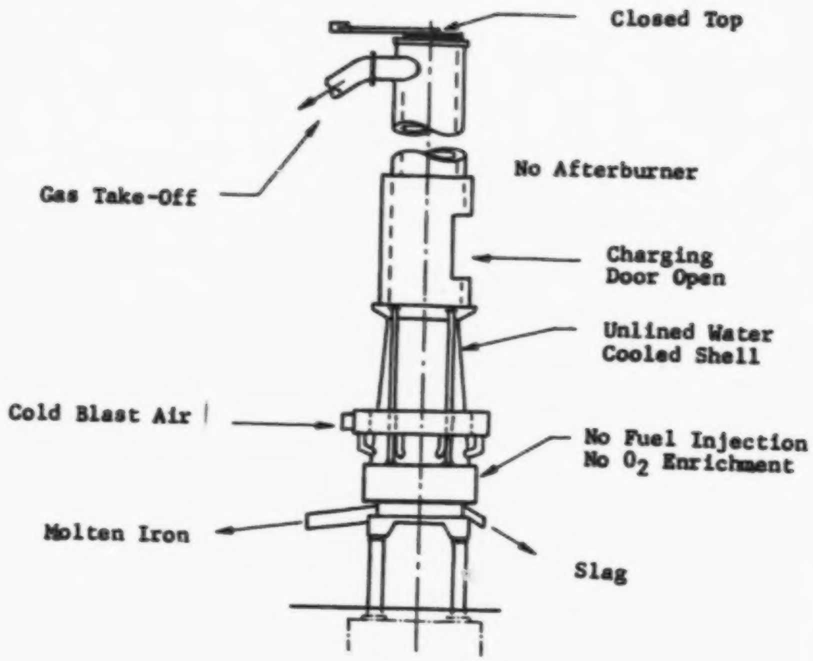
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	100823.	98.35
SENSIBLE HEAT OF THE BLAST	158.	0.15
HEAT FROM OXIDATION OF MN, FE, SI	1537.	1.50
TOTAL INPUT HEAT	102518.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	38157.	37.22
HEAT CONTENT OF THE SLAG	598.	0.58
CALCINING OF LIMESTONE	1438.	1.40
DECOMPOSITION OF WATER	1388.	1.35
TOP GASES		
-SENSIBLE HEAT	14714.	14.35
-LATENT HEAT	32509.	31.71
HEAT RADIATION FROM THE CUPOLA	13714.	13.38

VOLUME OF TOP GAS (MCF)
ACTUAL 2309.
STANDARD 917.

MATERIAL BALANCE

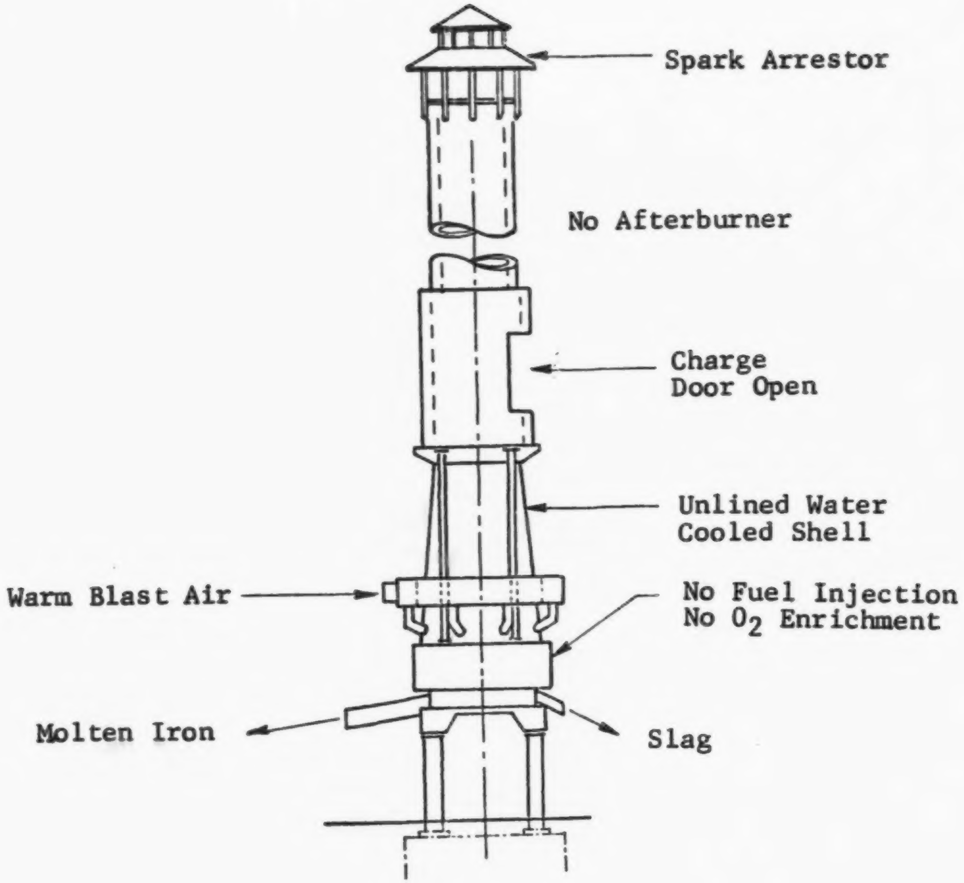
INPUTS	POUNDS	PERCENT
METAL CHARGE	1992.	47.42
PIG IRON	233.	5.56
RETURNS	996.	23.71
STEEL SCRAP	739.	17.60
IRON SCRAP	0.	0.00
FERROALLOYS	23.	0.56
COKE	253.	6.03
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	58.	1.38
AIR	1898.	45.18
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	4201.	100.00
OUTPUTS		
MOLTEN IRON	2000.	47.60
SLAG	44.	1.04
EMISSIONS DUST	19.	0.45
TOP GASES	2139.	50.90
NITROGEN	1449.	67.77
CARBON DIOXIDE	468.	21.87
CARBON MONOXIDE	220.	10.29
HYDROGEN	2.	0.07
SULFUR DIOXIDE	-0.	-0.00


Closed Top
No Afterburner
Gas Take-Off
Charging Door Open
Unlined Water Cooled Shell
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 2

APPENDIX C
EXHIBIT 3
PAGE 2

Insufficient Data for
Heat and Material
Balance Calculations


Spark Arrestor
No Afterburner
Charge
Door Open
Unlined Water
Cooled Shell
Warm Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 3

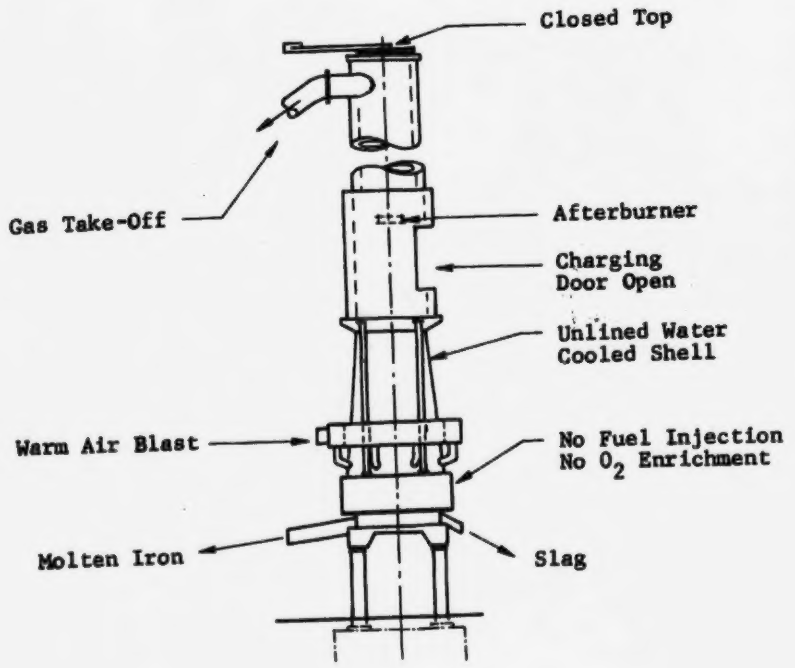
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	56685.	85.19
SENSIBLE HEAT OF THE BLAST	9301.	13.98
HEAT FROM OXIDATION OF MN, FE, SI	556.	0.84
TOTAL INPUT HEAT	66541.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	15432.	23.19
HEAT CONTENT OF THE SLAG	156.	0.23
CALCINING OF LIMESTONE	984.	1.48
DECOMPOSITION OF WATER	680.	1.02
TOP GASES		
-SENSIBLE HEAT	11973.	17.99
-LATENT HEAT	-15611.	-23.46
HEAT RADIATION FROM THE CUPOLA	52926.	79.54

VOLUME OF TOP GAS (MCF)
ACTUAL 1793.
STANDARD 712.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2004.	30.73
PIG IRON	0.	0.00
RETURNS	982.	15.05
STEEL SCRAP	295.	4.52
IRON SCRAP	687.	10.54
FERROALLOYS	41.	0.62
COKE	333.	5.11
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	100.	1.54
AIR	4085.	62.63
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	6523.	100.00
OUTPUTS		
MOLTEN IRON	2000.	30.66
SLAG	56.	0.86
EMISSIONS DUST	32.	0.49
TOP GASES	4435.	67.99
NITROGEN	3129.	70.55
CARBON DIOXIDE	1573.	35.46
CARBON MONOXIDE	-266.	-6.00
HYDROGEN	2.	0.04
SULFUR DIOXIDE	-3.	-0.06


Closed Top
Gas Take-Off
Afterburner
Charging Door Open
Unlined Water Cooled Shell
Warm Air Blast
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 4

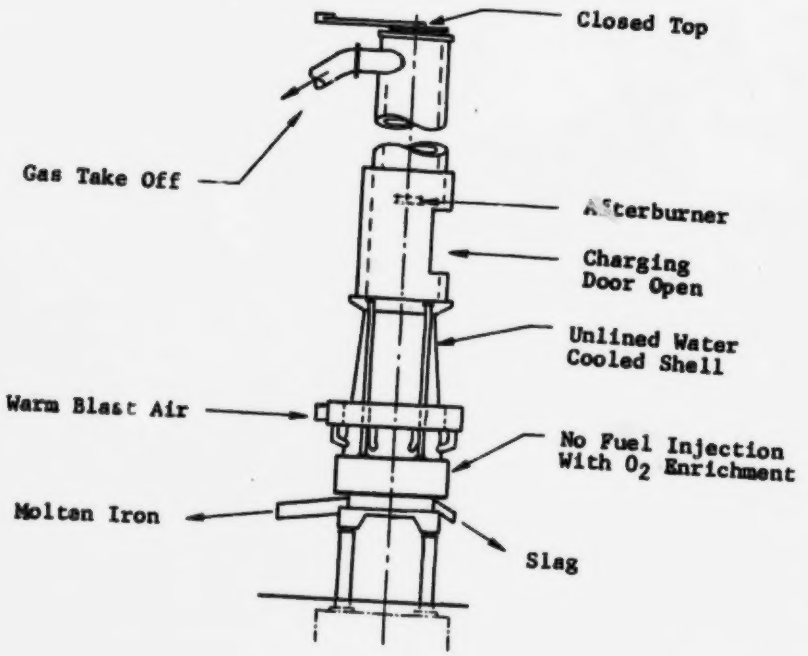
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	40947.	86.57
SENSIBLE HEAT OF THE BLAST	3247.	6.86
HEAT FROM OXIDATION OF MN, FE, SI	3106.	6.57
TOTAL INPUT HEAT	47300.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	14028.	29.66
HEAT CONTENT OF THE SLAG	806.	1.70
CALCINING OF LIMESTONE	1221.	2.58
DECOMPOSITION OF WATER	292.	0.62
TOP GASES		
-SENSIBLE HEAT	5652.	11.95
-LATENT HEAT	10785.	22.80
HEAT RADIATION FROM THE CUPOLA	14515.	30.69

VOLUME OF TOP GAS (MCF)	
ACTUAL	872.
STANDARD	346.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2030.	46.23
PIG IRON	256.	5.83
RETURNS	1507.	34.32
STEEL SCRAP	0.	0.00
IRON SCRAP	223.	5.07
FERROALLOYS	45.	1.01
COKE	250.	5.69
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	136.	3.10
AIR	1893.	43.13
OXYGEN	81.	1.85
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	4390.	100.00
OUTPUTS		
MOLTEN IRON	2000.	45.55
SLAG	120.	2.74
EMISSIONS DUST	19.	0.44
TOP GASES	2251.	51.27
NITROGEN	1450.	64.43
CARBON DIOXIDE	600.	26.65
CARBON MONOXIDE	199.	8.82
HYDROGEN	1.	0.04
SULFUR DIOXIDE	1.	0.06


Closed Top
Gas Take Off
Afterburner
Charging Door Open
Unlined Water Cooled Shell
Warm Blast Air
No Fuel Injection With O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 5

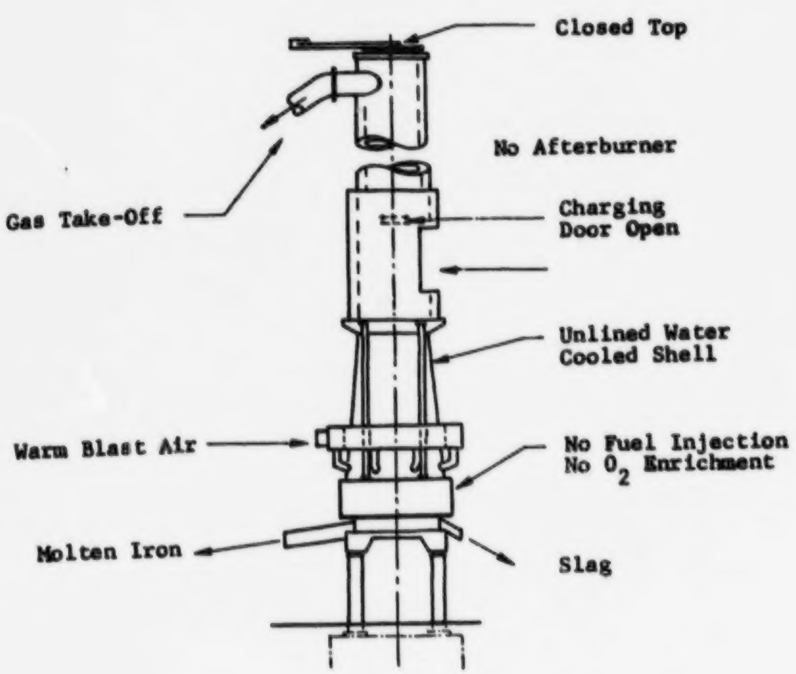
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	44940.	89.05
SENSIBLE HEAT OF THE BLAST	4694.	9.30
HEAT FROM OXIDATION OF MN, FE, SI	834.	1.65
TOTAL INPUT HEAT	50468.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	23343.	46.25
HEAT CONTENT OF THE SLAG	706.	1.40
CALCINING OF LIMESTONE	326.	0.64
DECOMPOSITION OF WATER	615.	1.22
TOP GASES		
-SENSIBLE HEAT	6892.	13.66
-LATENT HEAT	14898.	29.52
HEAT RADIATION FROM THE CUPOLA	3688.	7.31

VOLUME OF TOP GAS (MCF)	
ACTUAL	1059.
STANDARD	405.

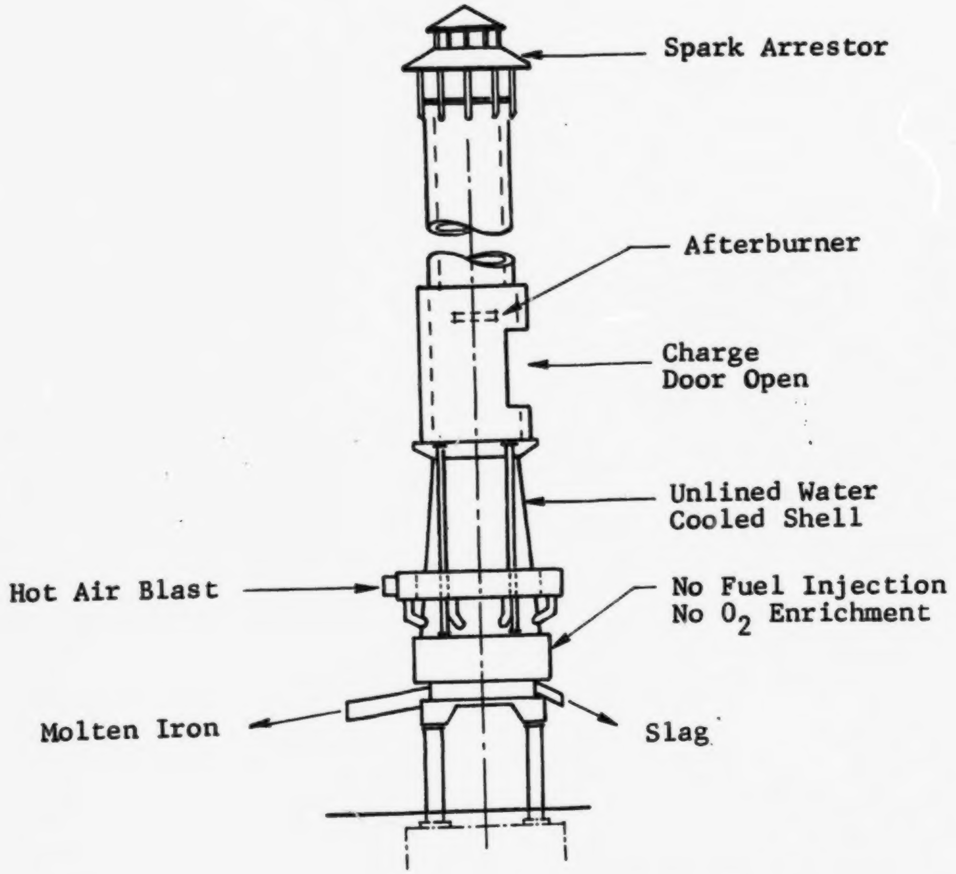
MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1981.	55.05
PIG IRON	0.	0.00
RETURNS	869.	24.14
STEEL SCRAP	1043.	28.97
IRON SCRAP	0.	0.00
FERROALLOYS	70.	1.93
COKE	200.	5.56
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	44.	1.21
AIR	1374.	38.18
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	3599.	100.00
OUTPUTS		
MOLTEN IRON	2000.	55.57
SLAG	45.	1.26
EMISSIONS DUST	14.	0.38
TOP GASES	1540.	42.79
NITROGEN	1049.	68.13
CARBON DIOXIDE	324.	21.05
CARBON MONOXIDE	165.	10.70
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.04


Closed Top
No Afterburner
Gas Take-Off
Charging Door Open
Unlined Water Cooled Shell
Warm Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 6

Insufficient Data for
Heat and Material
Balance Calculations


Spark Arrestor
Afterburner
Charge Door Open
Unlined Water Cooled Shell
Hot Air Blast
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 7

HEAT BALANCE

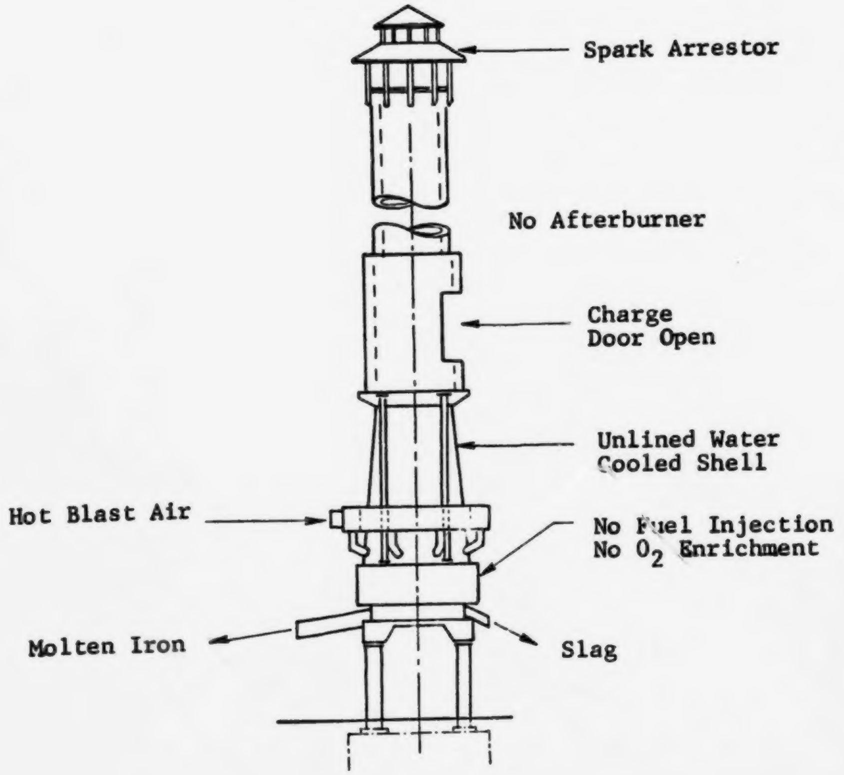
INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	64255.	76.64
SENSIBLE HEAT ØF THE BLAST	12745.	15.20
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	6840.	8.16
TØTAL INPUT HEAT	83840.	100.00
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	22863.	27.27
HEAT CØNTENT ØF THE SLAG	1271.	1.52
CALCINING ØF LIMESTØNE	875.	1.04
DECØMPØSITIØN ØF WATER	1190.	1.42
TØP GASES		
-SENSIBLE HEAT	12113.	14.45
-LATENT HEAT	356.	0.42
HEAT RADIATIØN FRØM THE CUPØLA	45172.	53.88

VØLUME ØF TØP GAS (MCF)

ACTUAL	1853.
STANDARD	736.

MATERIAL BALANCE

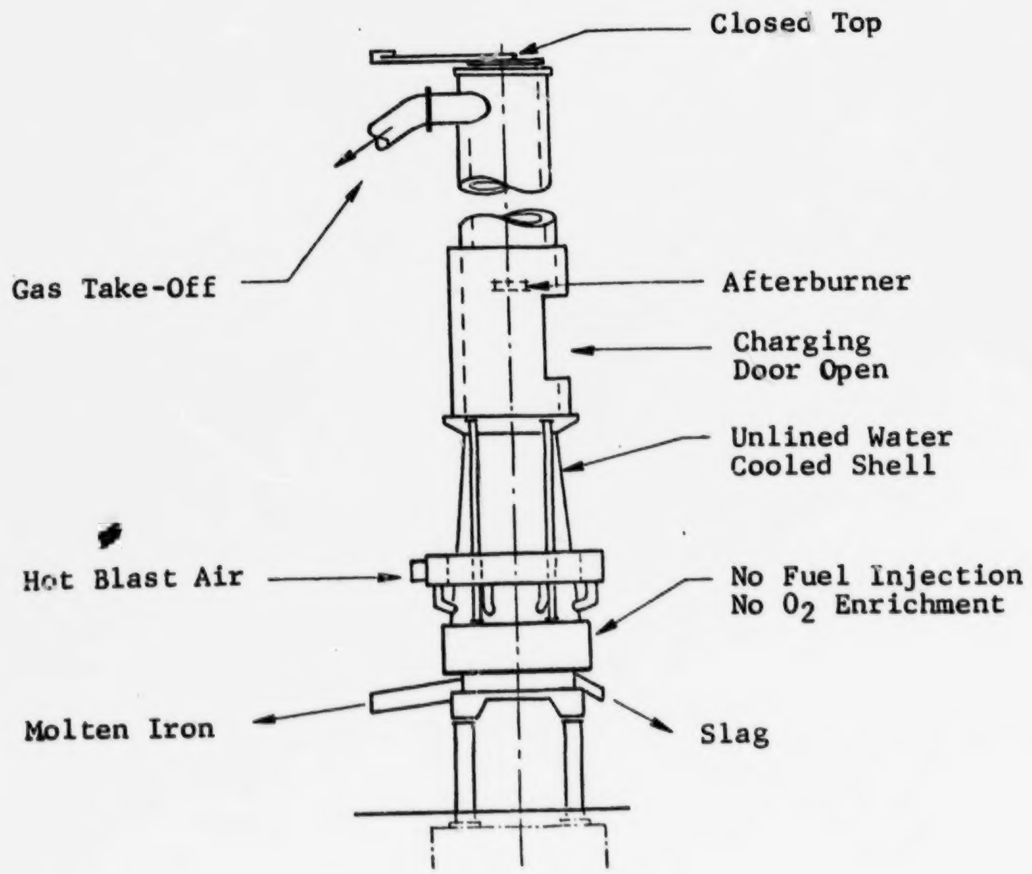
INPUTS	PØUNDS	PERCENT
METAL CHARGE	2023.	39.54
PIG IRØN	0.	0.00
RETURNS	587.	11.47
STEEL SCRAP	391.	7.65
IRØN SCRAP	978.	19.12
FERRØALLØYS	67.	1.30
CØKE	267.	5.21
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	61.	1.19
AIR	2766.	54.06
ØXYGEN	0.	0.00
CUPØLA LINING	0.	0.00
TØTAL INPUT MTLS	5117.	100.00
ØUTPUTS		
MØLTEN IRØN	2000.	39.09
SLAG	84.	1.63
EMISSIØNS DUST	26.	0.50
TØP GASES	3008.	58.78
NITRØGEN	2112.	70.22
CARBØN DIØXIDE	887.	29.48
CARBØN MØNØXIDE	4.	0.14
HYDRØGEN	2.	0.08
SULFUR DIØXIDE	2.	0.08


Spark Arrestor
No Afterburner
Charge Door Open
Unlined Water Cooled Shell
Hot Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 8

APPENDIX C
EXHIBIT 3
PAGE 8

Insufficient Data for
Heat and Material
Balance Calculations


Closed Top
Gas Take-Off
Afterburner
Charging
Door Open
Unlined Water
Cooled Shell
Hot Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 9

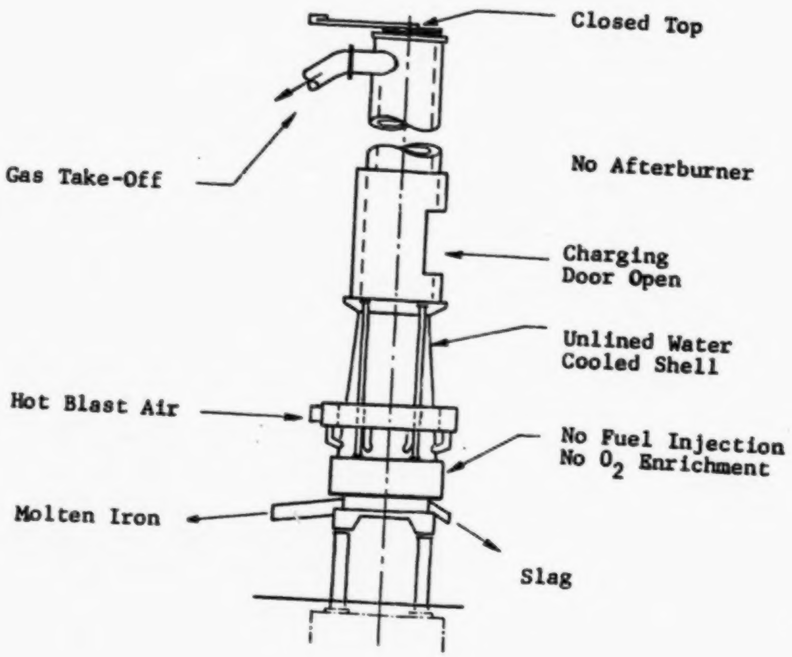
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	39360.	56.01
SENSIBLE HEAT OF THE BLAST	6373.	9.07
HEAT FROM OXIDATION OF MN, FE, SI	24545.	34.93
TOTAL INPUT HEAT	70278.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	11223.	15.97
HEAT CONTENT OF THE SLAG	4148.	5.90
CALCINING OF LIMESTONE	795.	1.13
DECOMPOSITION OF WATER	595.	0.85
TOP GASES		
-SENSIBLE HEAT	5902.	8.40
-LATENT HEAT	24225.	34.47
HEAT RADIATION FROM THE CUPOLA	23390.	33.28

VOLUME OF TOP GAS (MCF)
ACTUAL 971.
STANDARD 386.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2190.	40.38
PIG IRON	0.	0.00
RETURNS	640.	11.81
STEEL SCRAP	0.	0.00
IRON SCRAP	1121.	20.66
FERROALLOYS	429.	7.91
COKE	320.	5.90
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	119.	2.20
AIR	2766.	50.99
OXYGEN	0.	0.00
CUPOLA LINING	29.	0.54
TOTAL INPUT MTLS	5425.	100.00
OUTPUTS		
MOLTEN IRON	2000.	36.87
SLAG	501.	9.24
EMISSIONS DUST	27.	0.49
TOP GASES	2897.	53.40
NITROGEN	2112.	72.91
CARBON DIOXIDE	222.	7.67
CARBON MONOXIDE	557.	19.24
HYDROGEN	2.	0.08
SULFUR DIOXIDE	3.	0.10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Gas Take-Off
No Afterburner
Charging Door Open
Unlined Water Cooled Shell
Hot Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 10

APPENDIX C
EXHIBIT 3
PAGE 10

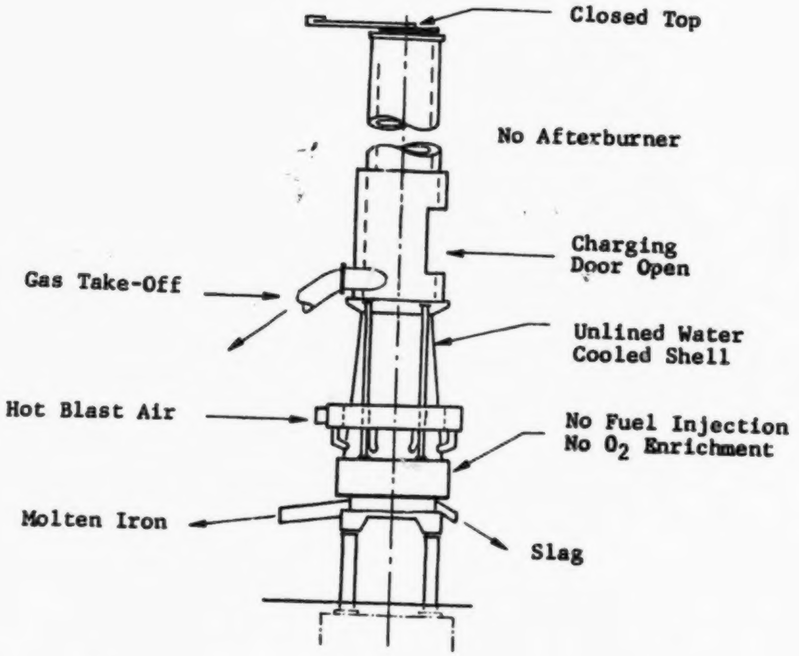
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	94371.	88.08
SENSIBLE HEAT OF THE BLAST	11389.	10.63
HEAT FROM OXIDATION OF MN, FE, SI	1386.	1.29
TOTAL INPUT HEAT	107146.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	39279.	36.66
HEAT CONTENT OF THE SLAG	505.	0.47
CALCINING OF LIMESTONE	786.	0.73
DECOMPOSITION OF WATER	1190.	1.11
TOP GASES		
-SENSIBLE HEAT	12693.	11.85
-LATENT HEAT	39035.	36.43
HEAT RADIATION FROM THE CUPOLA	13658.	12.75

VOLUME OF TOP GAS (MCF)
ACTUAL 2018.
STANDARD 801.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1989.	51.90
PIG IRON	0.	0.00
RETURNS	426.	11.12
STEEL SCRAP	791.	20.65
IRON SCRAP	761.	19.85
FERROALLOYS	11.	0.28
COKE	233.	6.07
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	31.	0.80
AIR	1581.	41.24
OXYGEN	0.	0.00
CUPOLA LINING	0.	0.00
TOTAL INPUT MTLS	3833.	100.00
OUTPUTS		
MOLTEN IRON	2000.	52.18
SLAG	27.	0.70
EMISSIONS DUST	16.	0.42
TOP GASES	1790.	46.70
NITROGEN	1207.	67.43
CARBON DIOXIDE	324.	18.09
CARBON MONOXIDE	257.	14.34
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.08


Closed Top
No Afterburner
Charging Door Open
Gas Take-Off
Unlined Water Cooled Shell
Hot Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 11

APPENDIX C
EXHIBIT 3
PAGE 11

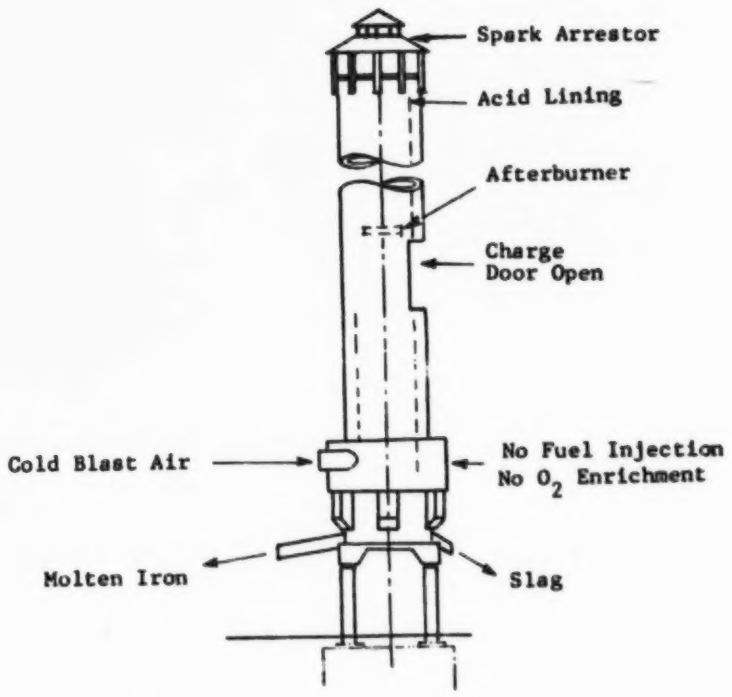
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	29060.	86.72
SENSIBLE HEAT OF THE BLAST	61.	0.18
HEAT FROM OXIDATION OF MN, FE, SI	4390.	13.10
TOTAL INPUT HEAT	33511.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	17623.	52.59
HEAT CONTENT OF THE SLAG	274.	0.82
CALCINING OF LIMESTONE	756.	2.25
DECOMPOSITION OF WATER	3569.	10.65
TOP GASES		
-SENSIBLE HEAT	6182.	18.45
-LATENT HEAT	6880.	20.53
HEAT RADIATION FROM THE CUPOLA	-1772.	-5.29

VOLUME OF TOP GAS (MCF)
ACTUAL 952.
STANDARD 375.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2004.	52.08
PIG IRON	0.	0.00
RETURNS	802.	20.83
STEEL SCRAP	1137.	29.56
IRON SCRAP	0.	0.00
FERROALLOYS	65.	1.69
COKE	167.	4.33
NATURAL GAS	29.	0.75
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	65.	1.69
AIR	1556.	40.43
OXYGEN	0.	0.00
CUPOLA LINING	27.	0.71
TOTAL INPUT MTLS	3848.	100.00
OUTPUTS		
MOLTEN IRON	2000.	51.97
SLAG	32.	0.83
EMISSIONS DUST	14.	0.37
TOP GASES	1802.	46.84
NITROGEN	1188.	65.91
CARBON DIOXIDE	507.	28.10
CARBON MONOXIDE	99.	5.49
HYDROGEN	9.	0.47
SULFUR DIOXIDE	0.	0.02


Spark Arrestor
Acid Lining
Afterburner
Charge Door Open
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 12

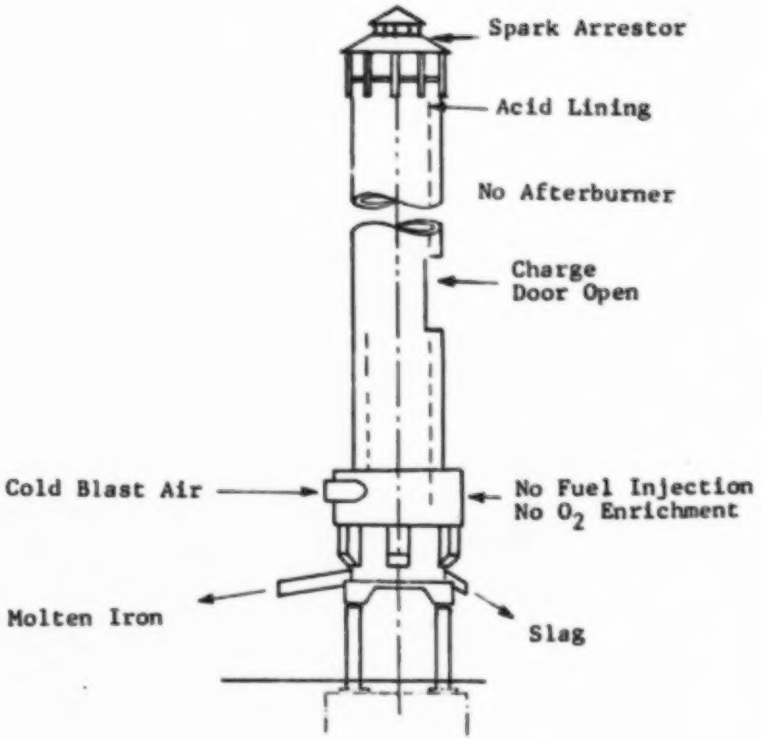
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	51194.	98.50
SENSIBLE HEAT OF THE BLAST	90.	0.17
HEAT FROM OXIDATION OF MN, FE, SI	691.	1.33
TOTAL INPUT HEAT	51976.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	15712.	30.23
HEAT CONTENT OF THE SLAG	511.	0.98
CALCINING OF LIMESTONE	674.	1.30
DECOMPOSITION OF WATER	793.	1.53
TOP GASES		
-SENSIBLE HEAT	8281.	15.93
-LATENT HEAT	9439.	18.16
HEAT RADIATION FROM THE CUPOLA	16567.	31.87

VOLUME OF TOP GAS (MCF)
ACTUAL 1283.
STANDARD 509.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1994.	39.73
PIG IRON	389.	7.75
RETURNS	803.	15.99
STEEL SCRAP	730.	14.53
IRON SCRAP	49.	0.97
FERROALLOYS	24.	0.48
COKE	308.	6.13
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	66.	1.31
AIR	2634.	52.48
OXYGEN	0.	0.00
CUPOLA LINING	18.	0.35
TOTAL INPUT MTLS	5020.	100.00
OUTPUTS		
MOLTEN IRON	2000.	39.84
SLAG	64.	1.27
EMISSIONS DUST	24.	0.47
TOP GASES	2932.	58.42
NITROGEN	2011.	68.59
CARBON DIOXIDE	762.	25.99
CARBON MONOXIDE	155.	5.29
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.05


Spark Arrestor
Acid Lining
No Afterburner
Charge Door Open
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 13

APPENDIX C
EXHIBIT 3

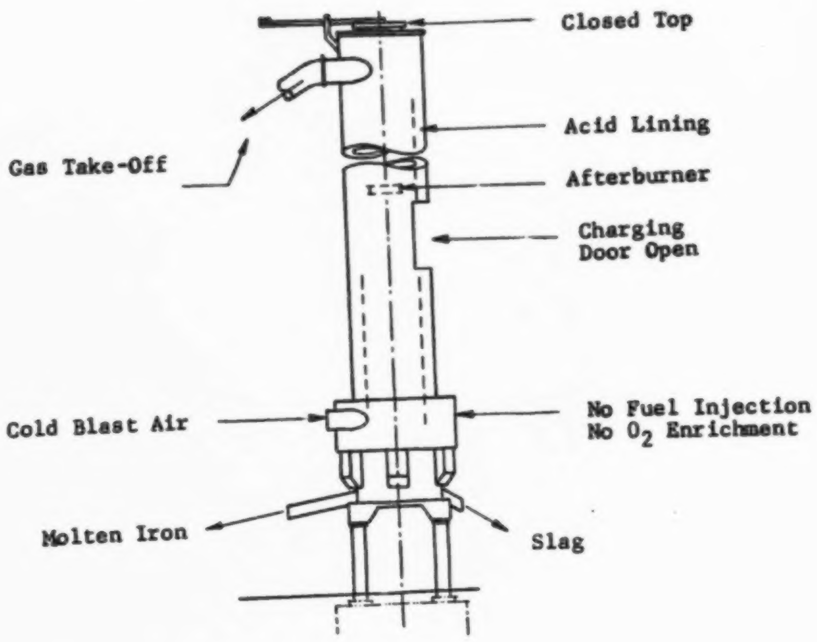
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	31164.	98.54
SENSIBLE HEAT OF THE BLAST	49.	0.16
HEAT FROM OXIDATION OF MN, FE, SI	414.	1.31
TOTAL INPUT HEAT	31628.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	11160.	35.29
HEAT CONTENT OF THE SLAG	459.	1.45
CALCINING OF LIMESTONE	547.	1.73
DECOMPOSITION OF WATER	431.	1.36
TOP GASES		
-SENSIBLE HEAT	4581.	14.48
-LATENT HEAT	9802.	30.99
HEAT RADIATION FROM THE CUPOLA	4647.	14.69

VOLUME OF TOP GAS (MCF)
ACTUAL 719.
STANDARD 285.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2005.	45.94
PIG IRON	0.	0.00
RETURNS	201.	4.59
STEEL SCRAP	301.	6.89
IRON SCRAP	1504.	34.45
FERROALLOYS	0.	0.00
COKE	250.	5.73
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	75.	1.73
AIR	2005.	45.94
OXYGEN	0.	0.00
CUPOLA LINING	29.	0.67
TOTAL INPUT MTLS	4365.	100.00
OUTPUTS		
MOLTEN IRON	2000.	45.82
SLAG	77.	1.77
EMISSIONS DUST	19.	0.43
TOP GASES	2269.	51.99
NITROGEN	1531.	67.47
CARBON DIOXIDE	507.	22.34
CARBON MONOXIDE	226.	9.94
HYDROGEN	2.	0.07
SULFUR DIOXIDE	4.	0.18


Closed Top
Acid Lining
Gas Take-Off
Afterburner
Charging Door Open
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 14

APPENDIX C
EXHIBIT 3
PAGE 15

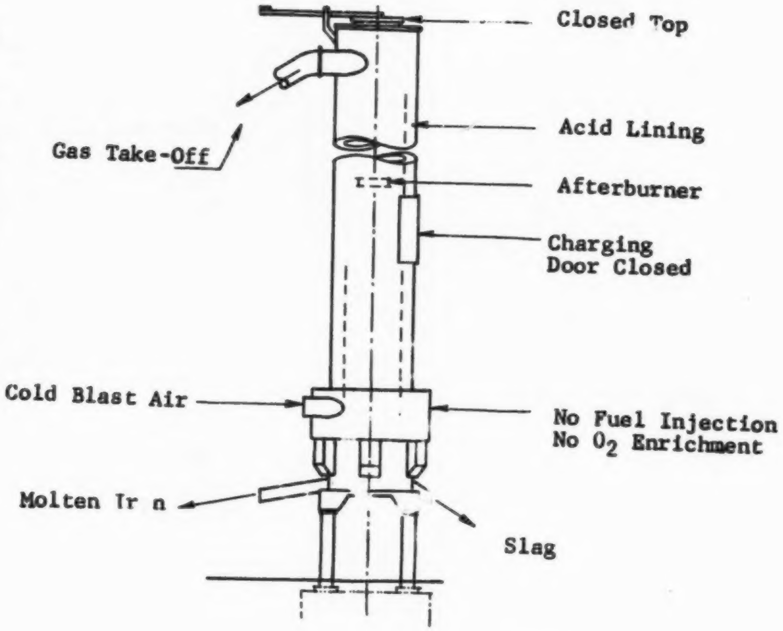
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	35065.	98.73
SENSIBLE HEAT OF THE BLAST	53.	0.15
HEAT FROM OXIDATION OF MN, FE, SI	399.	1.12
TOTAL INPUT HEAT	35518.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	9312.	26.22
HEAT CONTENT OF THE SLAG	420.	1.18
CALCINING OF LIMESTONE	350.	0.99
DECOMPOSITION OF WATER	466.	1.31
TOP GASES		
-SENSIBLE HEAT	4945.	13.92
-LATENT HEAT	12530.	35.28
HEAT RADIATION FROM THE CUPOLA	7495.	21.10

VOLUME OF TOP GAS (MCF)
ACTUAL 780.
STANDARD 310.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1999.	38.79
PIG IRON	400.	7.76
RETURNS	800.	15.52
STEEL SCRAP	600.	11.64
IRON SCRAP	200.	3.88
FERROALLOYS	0.	0.00
COKE	357.	6.93
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	60.	1.16
AIR	2709.	52.55
OXYGEN	0.	0.00
CUPOLA LINING	29.	0.56
TOTAL INPUT MTLS	5154.	100.00
OUTPUTS		
MOLTEN IRON	2000.	38.81
SLAG	72.	1.40
EMISSIONS DUST	26.	0.51
TOP GASES	3055.	59.28
NITROGEN	2068.	67.68
CARBON DIOXIDE	623.	20.38
CARBON MONOXIDE	360.	11.79
HYDROGEN	2.	0.07
SULFUR DIOXIDE	2.	0.07


Closed Top
Acid Lining
Gas Take-Off
Afterburner
Charging Door Closed
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Ir n
Slag

CUPOLA CLASSIFICATION - 15

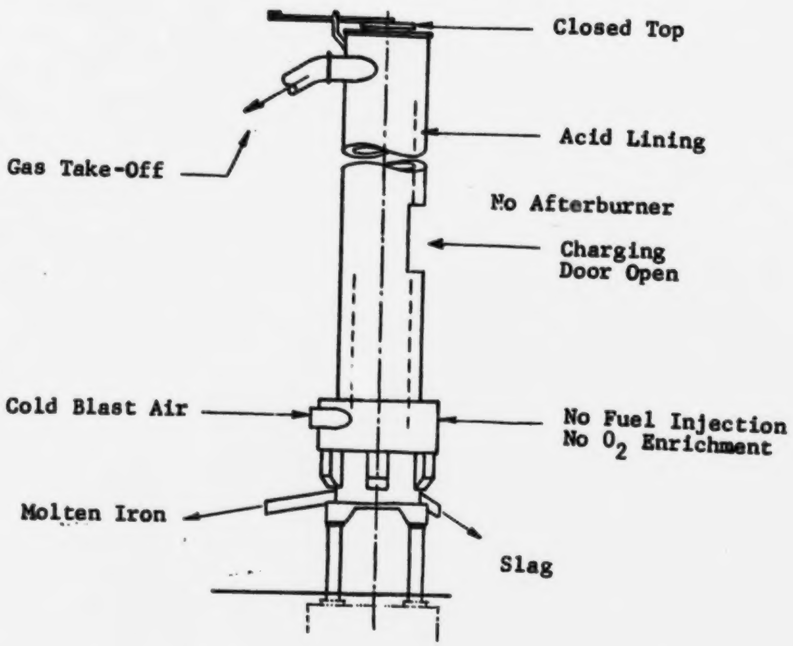
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	25435.	98.08
SENSIBLE HEAT OF THE BLAST	48.	0.19
HEAT FROM OXIDATION OF MN, FE, SI	450.	1.74
TOTAL INPUT HEAT	25934.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	9539.	36.78
HEAT CONTENT OF THE SLAG	485.	1.87
CALCINING OF LIMESTONE	322.	1.24
DECOMPOSITION OF WATER	421.	1.63
TOP GASES		
-SENSIBLE HEAT	4365.	16.83
-LATENT HEAT	2615.	10.08
HEAT RADIATION FROM THE CUPOLA	8186.	31.57

VOLUME OF TOP GAS (MCF)
ACTUAL 671.
STANDARD 266.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2002.	43.10
PIG IRON	548.	11.79
RETURNS	896.	19.30
STEEL SCRAP	548.	11.79
IRON SCRAP	0.	0.00
FERROALLOYS	10.	0.21
COKE	250.	5.38
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	52.	1.12
AIR	2305.	49.63
OXYGEN	0.	0.00
CUPOLA LINING	36.	0.77
TOTAL INPUT MTLS	4644.	100.00
OUTPUTS		
MOLTEN IRON	2000.	43.06
SLAG	76.	1.64
EMISSIONS DUST	21.	0.45
TOP GASES	2547.	54.85
NITROGEN	1760.	69.09
CARBON DIOXIDE	714.	28.03
CARBON MONOXIDE	71.	2.78
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.03


Closed Top
Acid Lining
Gas Take-Off
No Afterburner
Charging Door Open
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 16

APPENDIX C
EXHIBIT 3
PAGE 16

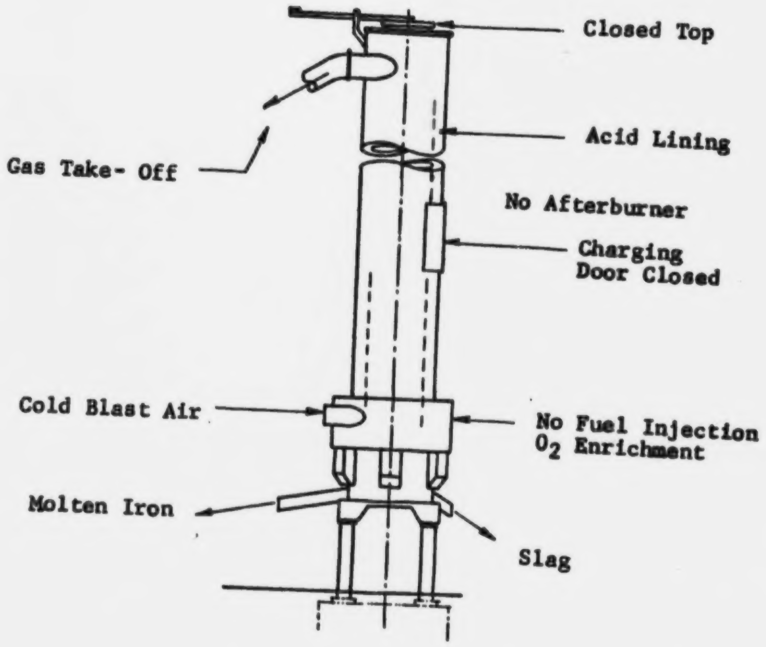
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	144207.	97.67
SENSIBLE HEAT OF THE BLAST	194.	0.13
HEAT FROM OXIDATION OF MN, FE, SI	3240.	2.19
TOTAL INPUT HEAT	147641.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	62872.	42.58
HEAT CONTENT OF THE SLAG	2249.	1.52
CALCINING OF LIMESTONE	1604.	1.09
DECOMPOSITION OF WATER	1636.	1.11
TOP GASES		
-SENSIBLE HEAT	18321.	12.41
-LATENT HEAT	49633.	33.62
HEAT RADIATION FROM THE CUPOLA	11326.	7.67

VOLUME OF TOP GAS (MCF)
ACTUAL 2863.
STANDARD 1137.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1984.	53.30
PIG IRON	861.	23.13
RETURNS	186.	5.00
STEEL SCRAP	931.	25.01
IRON SCRAP	0.	0.00
FERROALLOYS	6.	0.16
COKE	242.	6.51
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	40.	1.07
AIR	1383.	37.16
OXYGEN	61.	1.64
CUPOLA LINING	12.	0.33
TOTAL INPUT MTLS	3722.	100.00
OUTPUTS		
MOLTEN IRON	2000.	53.73
SLAG	57.	1.52
EMISSIONS DUST	15.	0.40
TOP GASES	1651.	44.35
NITROGEN	1056.	63.97
CARBON DIOXIDE	382.	23.17
CARBON MONOXIDE	208.	12.58
HYDROGEN	1.	0.07
SULFUR DIOXIDE	4.	0.21


Closed Top
Gas Take- Off
Acid Lining
No Afterburner
Charging Door Closed
Cold Blast Air
No Fuel Injection
O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 17

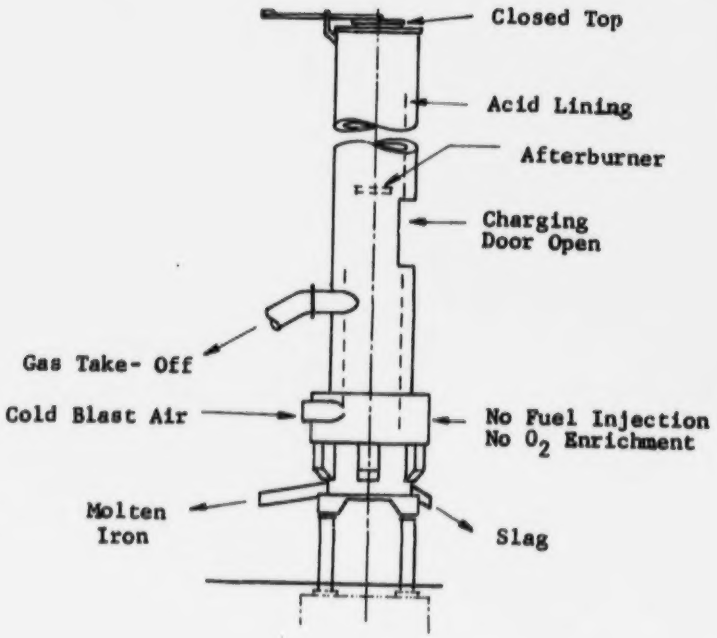
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	53096.	98.37
SENSIBLE HEAT OF THE BLAST	62.	0.12
HEAT FROM OXIDATION OF MN, FE, SI	816.	1.51
TOTAL INPUT HEAT	53975.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	22445.	41.59
HEAT CONTENT OF THE SLAG	885.	1.64
CALCINING OF LIMESTONE	816.	1.51
DECOMPOSITION OF WATER	545.	1.01
TOP GASES		
-SENSIBLE HEAT	6038.	11.19
-LATENT HEAT	31804.	58.92
HEAT RADIATION FROM THE CUPOLA	-8559.	-15.86

VOLUME OF TOP GAS (MCF)
ACTUAL 985.
STANDARD 391.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2002.	56.15
PIG IRON	0.	0.00
RETURNS	400.	11.23
STEEL SCRAP	400.	11.23
IRON SCRAP	1201.	33.69
FERROALLOYS	0.	0.00
COKE	222.	6.23
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	56.	1.57
AIR	1268.	35.56
OXYGEN	0.	0.00
CUPOLA LINING	18.	0.49
TOTAL INPUT MTLS	3566.	100.00
OUTPUTS		
MOLTEN IRON	2000.	56.09
SLAG	68.	1.90
EMISSIONS DUST	14.	0.40
TOP GASES	1484.	41.61
NITROGEN	968.	65.24
CARBON DIOXIDE	147.	9.90
CARBON MONOXIDE	366.	24.66
HYDROGEN	1.	0.07
SULFUR DIOXIDE	2.	0.12


Closed Top
Acid Lining
Afterburner
Charging Door Open
Gas Take- Off
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 18

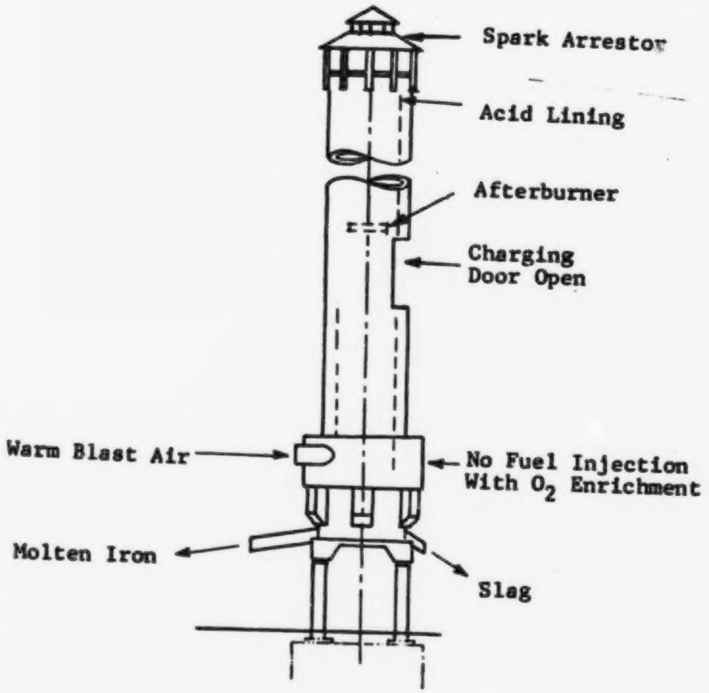
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	68407.	90.79
SENSIBLE HEAT OF THE BLAST	5504.	7.31
HEAT FROM OXIDATION OF MN, FE, SI	1434.	1.90
TOTAL INPUT HEAT	75345.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	25332.	33.62
HEAT CONTENT OF THE SLAG	1103.	1.46
CALCINING OF LIMESTONE	1604.	2.13
DECOMPOSITION OF WATER	567.	0.75
TOP GASES		
-SENSIBLE HEAT	11610.	15.41
-LATENT HEAT	17324.	22.99
HEAT RADIATION FROM THE CUPOLA	17804.	23.63

VOLUME OF TOP GAS (MCF)
ACTUAL 1734.
STANDARD 644.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2010.	44.99
PIG IRON	0.	0.00
RETURNS	1873.	41.91
STEEL SCRAP	125.	2.79
IRON SCRAP	0.	0.00
FERROALLOYS	13.	0.29
COKE	250.	5.59
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	101.	2.25
AIR	2089.	46.75
OXYGEN	0.	0.00
CUPOLA LINING	18.	0.41
TOTAL INPUT MTLS	4468.	100.00
OUTPUTS		
MOLTEN IRON	2000.	44.76
SLAG	93.	2.08
EMISSIONS DUST	20.	0.46
TOP GASES	2355.	52.70
NITROGEN	1600.	67.94
CARBON DIOXIDE	572.	24.27
CARBON MONOXIDE	181.	7.69
HYDROGEN	1.	0.04
SULFUR DIOXIDE	1.	0.05


Spark Arrestor
Acid Lining
Afterburner
Charging Door Open
Warm Blast Air
No Fuel Injection With O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 19

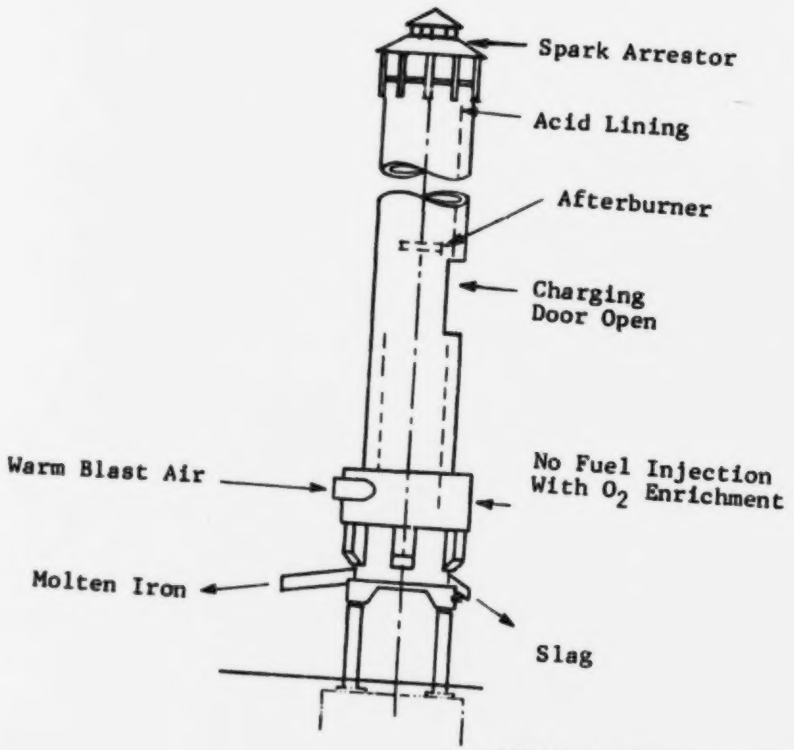
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	698[illegible].	87.22
SENSIBLE HEAT OF THE BLAST	9237.	11.53
HEAT FROM OXIDATION OF MN, FE, SI	1004.	1.25
TOTAL INPUT HEAT	80140.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	29100.	36.31
HEAT CONTENT OF THE SLAG	695.	0.87
CALCINING OF LIMESTONE	474.	0.59
DECOMPOSITION OF WATER	1190.	1.48
TOP GASES		
-SENSIBLE HEAT	12431.	15.51
-LATENT HEAT	-3301.	-4.12
HEAT RADIATION FROM THE CUPOLA	39552.	49.35

VOLUME OF TOP GAS (MCF)
ACTUAL 1879.
STANDARD 746.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	1983.	43.78
PIG IRON	0.	0.00
RETURNS	390.	8.60
STEEL SCRAP	974.	21.50
IRON SCRAP	584.	12.90
FERROALLOYS	35.	0.76
COKE	250.	5.52
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	26.	0.57
AIR	2213.	48.85
OXYGEN	41.	0.90
CUPOLA LINING	18.	0.39
TOTAL INPUT MTLS	4530.	100.00
OUTPUTS		
MOLTEN IRON	2000.	44.15
SLAG	36.	0.79
EMISSIONS DUST	22.	0.48
TOP GASES	2472.	54.58
NITROGEN	1690.	68.34
CARBON DIOXIDE	810.	32.76
CARBON MONOXIDE	-30.	-1.23
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.06


Spark Arrestor
Acid Lining
Afterburner
Charging Door Open
Warm Blast Air
No Fuel Injection With O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 20

APPENDIX C
EXHIBIT 3
PAGE 20

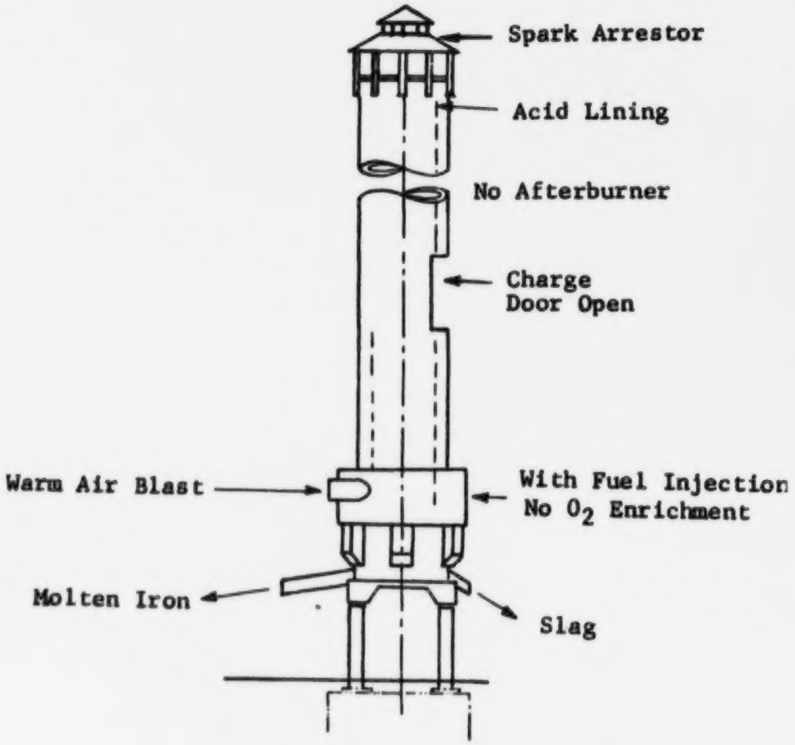
HEAT BALANCE

INPUT HEAT	B.T.U.S. (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	9985.	79.64
SENSIBLE HEAT OF THE BLAST	1337.	10.66
HEAT FROM OXIDATION OF MN, FE, SI	1216.	9.70
TOTAL INPUT HEAT	12538.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	3367.	26.85
HEAT CONTENT OF THE SLAG	401.	3.20
CALCINING OF LIMESTONE	262.	2.09
DECOMPOSITION OF WATER	198.	1.58
TOP GASES		
- SENSIBLE HEAT	3371.	26.89
- LATENT HEAT	13044.	-104.04
HEAT RADIATION FROM THE CUPOLA	17982.	143.42

VOLUME OF TOP GAS (MCF)
ACTUAL 487.
STANDARD 193.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2001.	25.42
PIG IRON	0.	0.00
RETURNS	566.	7.19
STEEL SCRAP	1321.	16.78
IRON SCRAP	0.	0.00
FERROALLOYS	113.	1.44
COKE	308.	3.91
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	120.	1.52
AIR	5361.	68.12
OXYGEN	0.	0.00
CUPOLA LINING	81.	1.03
TOTAL INPUT MTLS.	7871.	100.00
OUTPUTS		
MOLTEN IRON	2000.	25.41
SLAG	178.	2.26
EMISSIONS DUST	54.	0.69
TOP GASSES	5639.	71.64
NITROGEN	4107.	72.82
CARBON DIOXIDE	2529.	44.85
CARBON MONOXIDE	-1000.	-17.74
HYDROGEN	3.	0.04
SULFUR DIOXIDE	1.	0.03


Spark Arrestor
Acid Lining
No Afterburner
Charge Door Open
Warm Air Blast
With Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 21

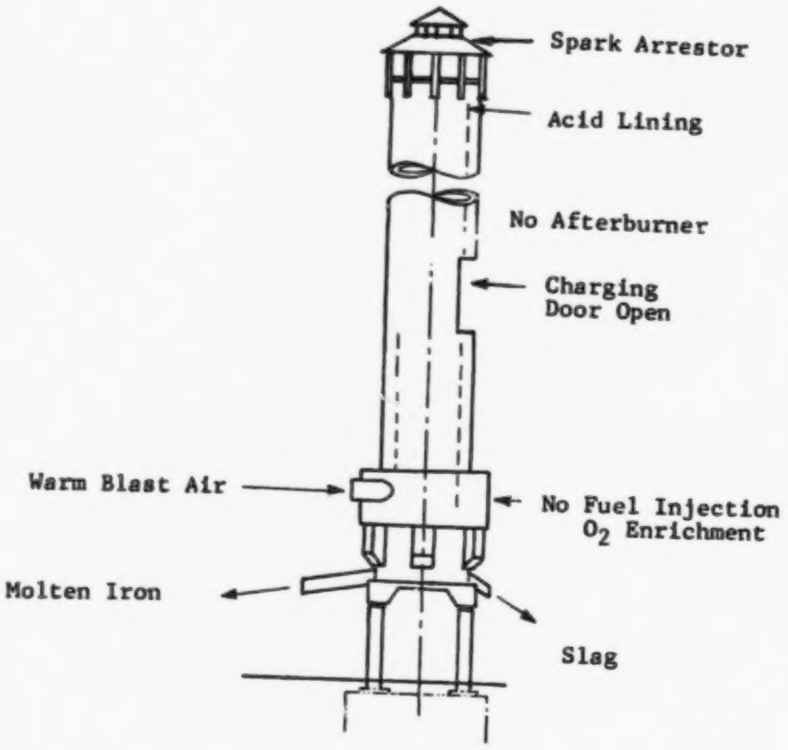
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	43896.	92.59
SENSIBLE HEAT OF THE BLAST	2600.	5.48
HEAT FROM OXIDATION OF MN, FE, SI	915.	1.93
TOTAL INPUT HEAT	47411.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	17956.	37.87
HEAT CONTENT OF THE SLAG	718.	1.51
CALCINING OF LIMESTONE	350.	0.74
DECOMPOSITION OF WATER	585.	1.23
TOP GASES		
-SENSIBLE HEAT	6186.	13.05
-LATENT HEAT	15923.	33.59
HEAT RADIATION FROM THE CUPOLA	5693.	12.01

VOLUME OF TOP GAS (MCF)
ACTUAL 978.
STANDARD 388.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2020.	50.68
PIG IRON	793.	19.90
RETURNS	793.	19.90
STEEL SCRAP	0.	0.00
IRON SCRAP	396.	9.95
FERROALLOYS	37.	0.93
COKE	211.	5.28
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	30.	0.76
AIR	1700.	42.67
OXYGEN	0.	0.00
CUPOLA LINING	24.	0.61
TOTAL INPUT MTLS	3985.	100.00
OUTPUTS		
MOLTEN IRON	2000.	50.19
SLAG	58.	1.45
EMISSIONS DUST	16.	0.40
TOP GASES	1911.	47.95
NITROGEN	1298.	67.93
CARBON DIOXIDE	381.	19.94
CARBON MONOXIDE	229.	11.98
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.07


Spark Arrestor
Acid Lining
No Afterburner
Charging Door Open
Warm Blast Air
No Fuel Injection
O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 22

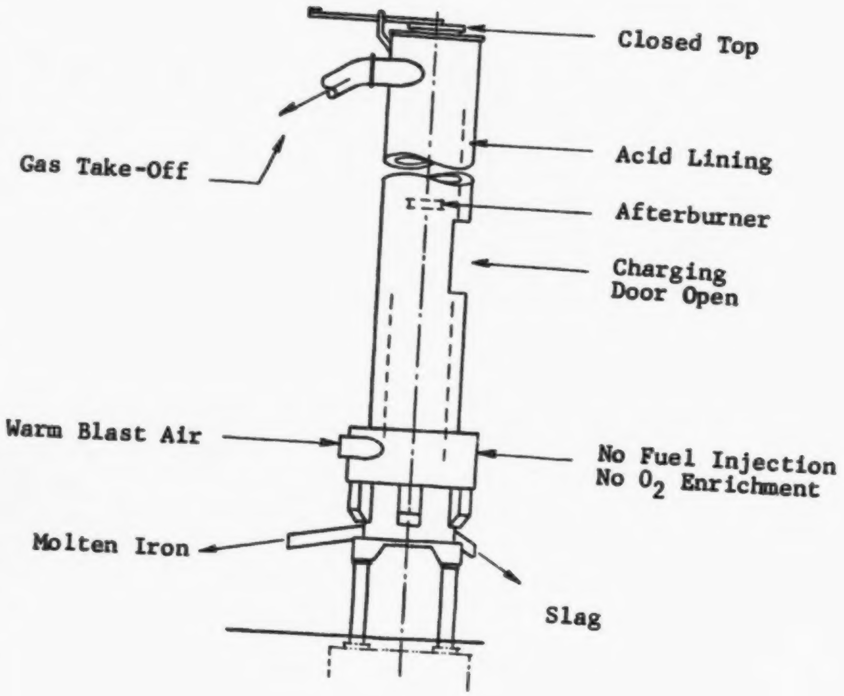
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	33777.	83.55
SENSIBLE HEAT OF THE BLAST	3977.	9.84
HEAT FROM OXIDATION OF MN, FE, SI	2673.	6.61
TOTAL INPUT HEAT	40427.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	18123.	44.83
HEAT CONTENT OF THE SLAG	1157.	2.86
CALCINING OF LIMESTONE	751.	1.86
DECOMPOSITION OF WATER	545.	1.35
TOP GASES		
-SENSIBLE HEAT	5668.	14.02
-LATENT HEAT	5977.	14.78
HEAT RADIATION FROM THE CUPOLA	8205.	20.29

VOLUME OF TOP GAS (MCF)
ACTUAL 878.
STANDARD 348.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2024.	52.36
PIG IRON	319.	8.25
RETURNS	996.	25.77
STEEL SCRAP	0.	0.00
IRON SCRAP	677.	17.52
FERROALLOYS	32.	0.82
COKE	167.	4.31
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	68.	1.76
AIR	1585.	40.99
OXYGEN	0.	0.00
CUPOLA LINING	22.	0.57
TOTAL INPUT MTLS	3866.	100.00
OUTPUTS		
MOLTEN IRON	2000.	51.73
SLAG	95.	2.46
EMISSIONS DUST	14.	0.35
TOP GASES	1757.	45.45
NITROGEN	1210.	68.87
CARBON DIOXIDE	459.	26.11
CARBON MONOXIDE	86.	4.89
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.06


Closed Top
Gas Take-Off
Acid Lining
Afterburner
Charging Door Open
Warm Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 23

APPENDIX C
EXHIBIT 3
PAGE 23

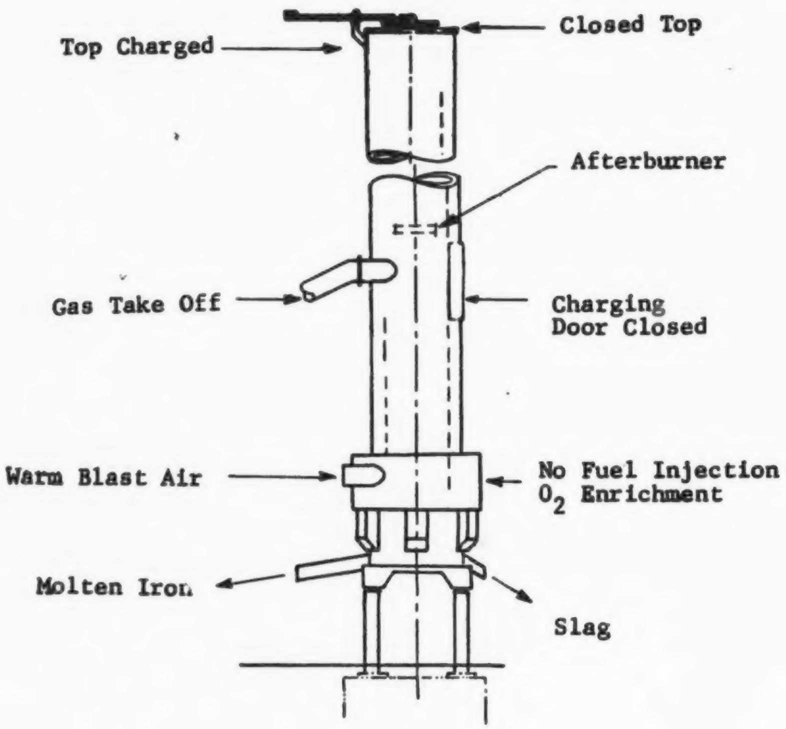
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	85775.	89.46
SENSIBLE HEAT OF THE BLAST	8173.	8.52
HEAT FROM OXIDATION OF MN, FE, SI	1937.	2.02
TOTAL INPUT HEAT	95886.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	43043.	44.89
HEAT CONTENT OF THE SLAG	1450.	1.51
CALCINING OF LIMESTONE	1219.	1.27
DECOMPOSITION OF WATER	1091.	1.14
TOP GASES		
-SENSIBLE HEAT	11927.	12.44
-LATENT HEAT	23741.	24.76
HEAT RADIATION FROM THE CUPOLA	13415.	13.99

VOLUME OF TOP GAS (MCF)
ACTUAL 1852.
STANDARD 735.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2009.	55.42
PIG IRON	502.	13.86
RETURNS	301.	8.31
STEEL SCRAP	301.	8.31
IRON SCRAP	904.	24.94
FERROALLOYS	0.	0.00
COKE	182.	5.02
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	44.	1.22
AIR	1335.	36.82
OXYGEN	40.	1.11
CUPOLA LINING	15.	0.42
TOTAL INPUT MTLS	3625.	100.00
OUTPUTS		
MOLTEN IRON	2000.	55.17
SLAG	56.	1.56
EMISSIONS DUST	12.	0.34
TOP GASES	1556.	42.92
NITROGEN	1019.	65.49
CARBON DIOXIDE	391.	25.14
CARBON MONOXIDE	144.	9.24
HYDROGEN	1.	0.07
SULFUR DIOXIDE	1.	0.06


Top Charged
Closed Top
Afterburner
Gas Take Off
Charging Door Closed
Warm Blast Air
No Fuel Injection
O_2 Enrichment
Molten Iron
Slag

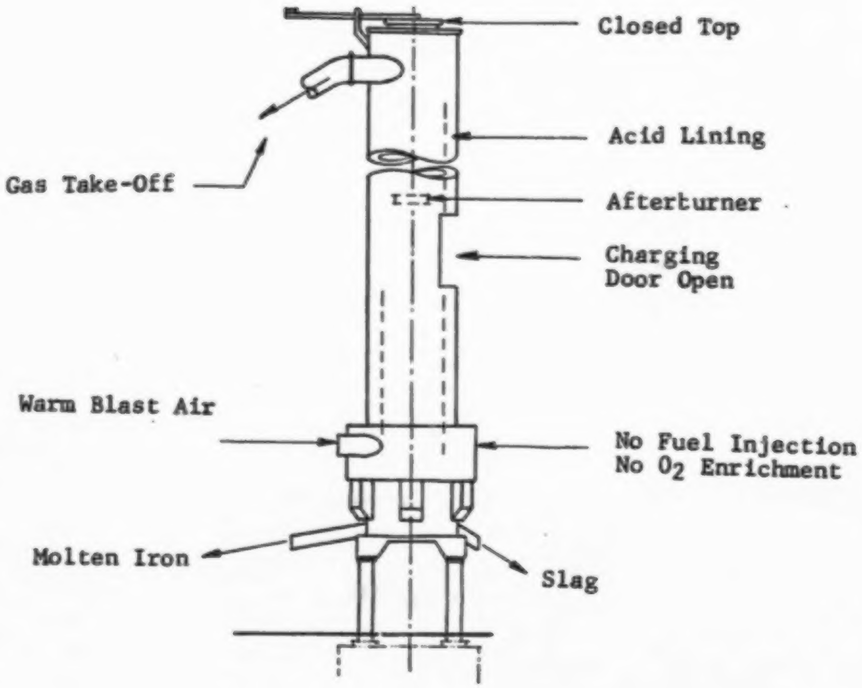
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	54422.	89.26
SENSIBLE HEAT OF THE BLAST	5225.	8.57
HEAT FROM OXIDATION OF MN, FE, SI	1323.	2.17
TOTAL INPUT HEAT	60970.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	28057.	46.02
HEAT CONTENT OF THE SLAG	797.	1.31
CALCINING OF LIMESTONE	1130.	1.85
DECOMPOSITION OF WATER	1349.	2.21
TOP GASES		
-SENSIBLE HEAT	13526.	22.19
-LATENT HEAT	-29511.	-48.40
HEAT RADIATION FROM THE CUPOLA	45622.	74.83

VOLUME OF TOP GAS (MCF)
ACTUAL 2000.
STANDARD 794.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2009.	42.04
PIG IRON	574.	12.01
RETURNS	954.	19.97
STEEL SCRAP	287.	6.01
IRON SCRAP	134.	2.80
FERROALLOYS	60.	1.25
COKE	182.	3.80
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	62.	1.30
AIR	2508.	52.48
OXYGEN	0.	0.00
CUPOLA LINING	18.	0.37
TOTAL INPUT MTLS	4779.	100.00
OUTPUTS		
MOLTEN IRON	2000.	41.85
SLAG	58.	1.22
EMISSIONS DUST	21.	0.45
TOP GASES	2699.	56.48
NITROGEN	1915.	70.95
CARBON DIOXIDE	1054.	39.04
CARBON MONOXIDE	-272.	-10.06
HYDROGEN	2.	0.08
SULFUR DIOXIDE	0.	0.00


Closed Top
Acid Lining
Gas Take-Off
Afterturner
Charging Door Open
Warm Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 25

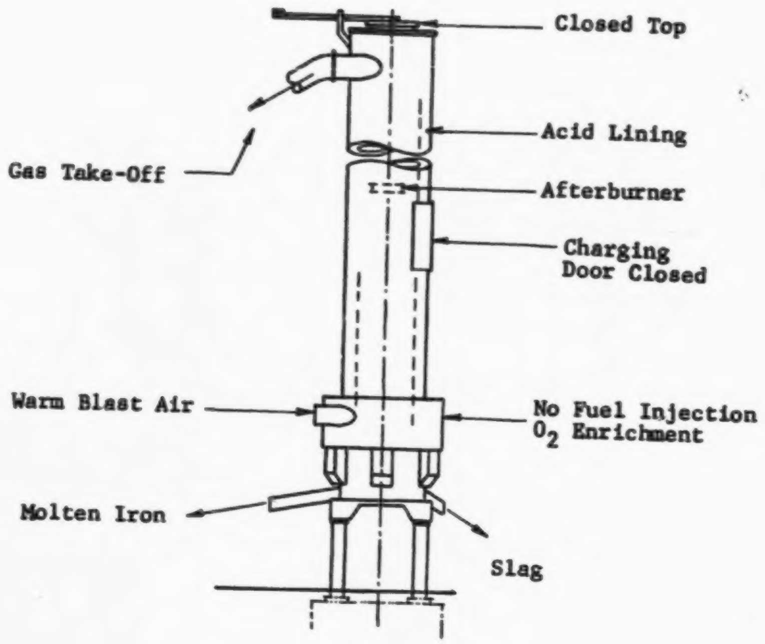
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	48492.	91.27
SENSIBLE HEAT OF THE BLAST	3539.	6.66
HEAT FROM OXIDATION OF MN, FE, SI	1102.	2.07
TOTAL INPUT HEAT	53133.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	24690.	46.47
HEAT CONTENT OF THE SLAG	949.	1.79
CALCINING OF LIMESTONE	898.	1.69
DECOMPOSITION OF WATER	1071.	2.02
TOP GASES		
-SENSIBLE HEAT	10842.	20.41
-LATENT HEAT	-16022.	-30.15
HEAT RADIATION FROM THE CUPOLA	30705.	57.79

VOLUME OF TOP GAS (MCF)
ACTUAL 1618.
STANDARD 642.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2001.	44.06
PIG IRON	429.	9.44
RETURNS	698.	15.37
STEEL SCRAP	498.	10.98
IRON SCRAP	343.	7.55
FERROALLOYS	34.	0.75
COKE	190.	4.20
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	56.	1.23
AIR	2263.	49.85
OXYGEN	0.	0.00
CUPOLA LINING	29.	0.64
TOTAL INPUT MTLS	4540.	100.00
OUTPUTS		
MOLTEN IRON	2000.	44.05
SLAG	65.	1.43
EMISSIONS DUST	23.	0.50
TOP GASES	2453.	54.02
NITROGEN	1728.	70.46
CARBON DIOXIDE	890.	36.28
CARBON MONOXIDE	-168.	-6.83
HYDROGEN	2.	0.08
SULFUR DIOXIDE	1.	0.03


Closed Top
Acid Lining
Gas Take-Off
Afterburner
Charging Door Closed
Warm Blast Air
No Fuel Injection
O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 26

APPENDIX C
EXHIBIT 3
PAGE 26

HEAT BALANCE

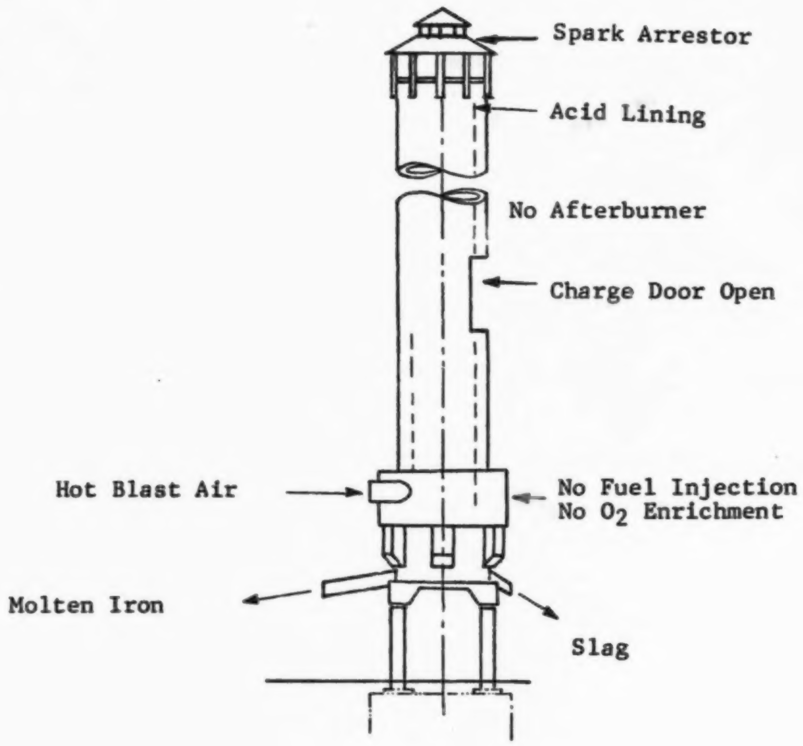
INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	97700.	80.01
SENSIBLE HEAT OF THE BLAST	22327.	18.28
HEAT FROM OXIDATION OF MN, FE, SI	2085.	1.71
TOTAL INPUT HEAT	122112.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	51441.	42.13
HEAT CONTENT OF THE SLAG	1122.	0.92
CALCINING OF LIMESTONE	1837.	1.50
DECOMPOSITION OF WATER	1884.	1.54
TOP GASES		
-SENSIBLE HEAT	19276.	15.79
-LATENT HEAT	-10714.	-8.77
HEAT RADIATION FROM THE CUPOLA	57267.	46.90

VOLUME OF TOP GAS (MCF)

ACTUAL	2917.
STANDARD	1158.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2012.	47.94
PIG IRON	287.	6.83
RETURNS	292.	6.97
STEEL SCRAP	143.	3.41
IRON SCRAP	1290.	30.73
FERROALLOYS	0.	0.00
COKE	174.	4.14
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	56.	1.34
AIR	1947.	46.38
OXYGEN	0.	0.00
CUPOLA LINING	8.	0.19
TOTAL INPUT MTLS	4196.	100.00
OUTPUTS		
MOLTEN IRON	2000.	47.66
SLAG	49.	1.17
EMISSIONS DUST	16.	0.37
TOP GASES	2132.	50.80
NITROGEN	1486.	69.72
CARBON DIOXIDE	698.	32.75
CARBON MONOXIDE	-55.	-2.57
HYDROGEN	2.	0.08
SULFUR DIOXIDE	0.	0.02


Spark Arrestor
Acid Lining
No Afterburner
Charge Door Open
Hot Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 27

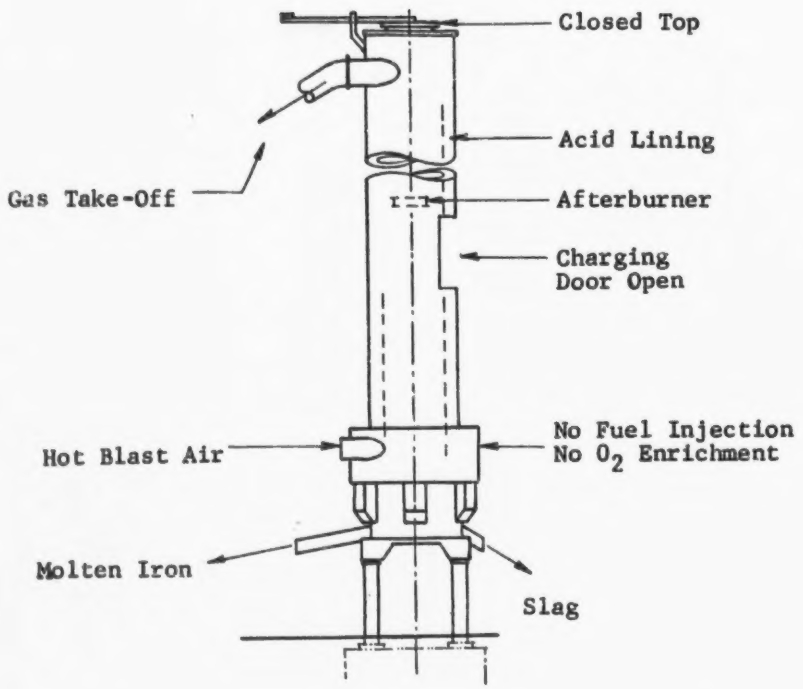
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	52620.	82.89
SENSIBLE HEAT OF THE BLAST	9878.	15.56
HEAT FROM OXIDATION OF MN, FE, SI	981.	1.54
TOTAL INPUT HEAT	63478.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	23029.	36.28
HEAT CONTENT OF THE SLAG	789.	1.24
CALCINING OF LIMESTONE	583.	0.92
DECOMPOSITION OF WATER	922.	1.45
TOP GASES		
-SENSIBLE HEAT	9487.	14.95
-LATENT HEAT	1458.	2.30
HEAT RADIATION FROM THE CUPOLA	27209.	42.86

VOLUME OF TOP GAS (MCF)
ACTUAL 1450.
STANDARD 576.

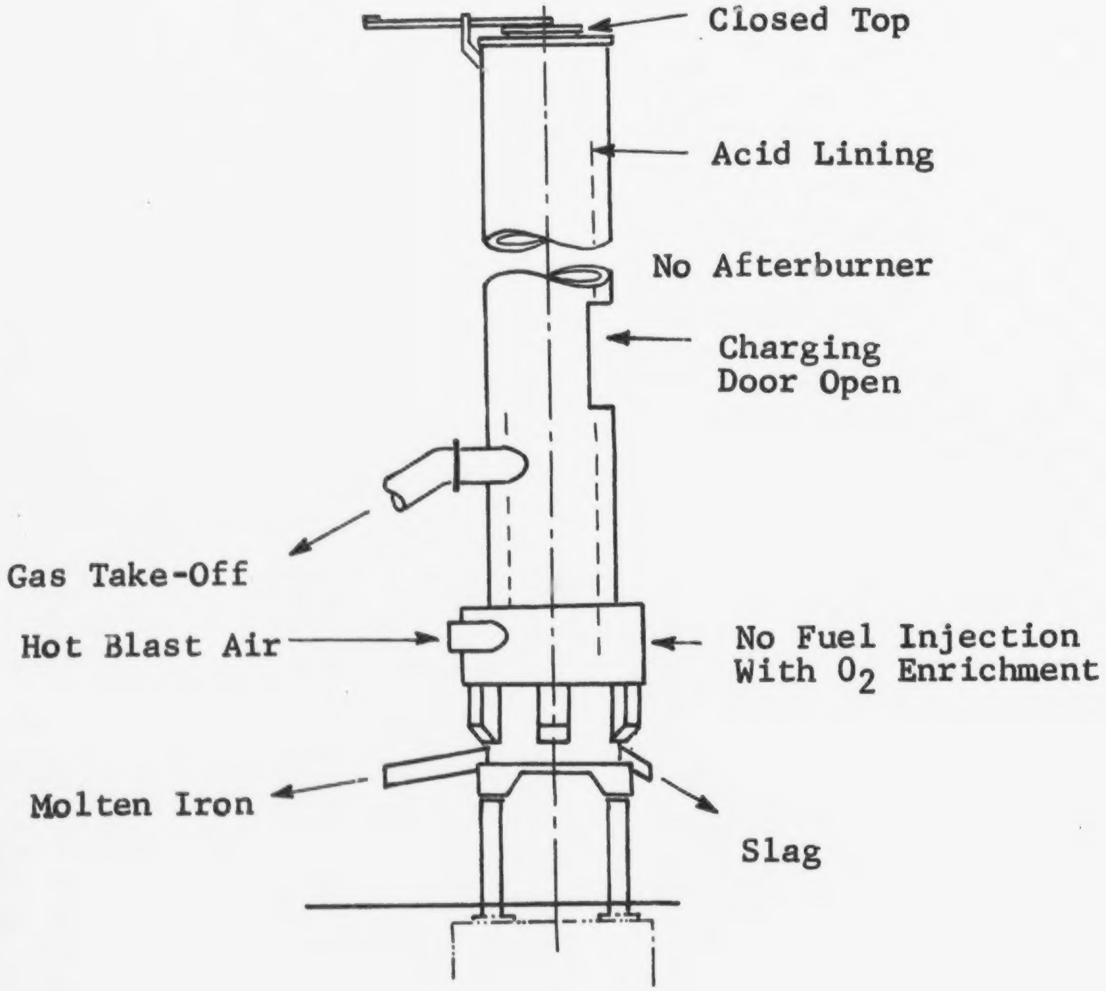
MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2001.	45.19
PIG IRON	400.	9.04
RETURNS	867.	19.58
STEEL SCRAP	534.	12.05
IRON SCRAP	200.	4.52
FERROALLOYS	0.	0.00
COKE	222.	5.02
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	40.	0.90
AIR	2144.	48.42
OXYGEN	0.	0.00
CUPOLA LINING	21.	0.47
TOTAL INPUT MTLS	4428.	100.00
OUTPUTS		
MOLTEN IRON	2000.	45.17
SLAG	53.	1.19
EMISSIONS DUST	20.	0.45
TOP GASES	2355.	53.19
NITROGEN	1637.	69.50
CARBON DIOXIDE	699.	29.67
CARBON MONOXIDE	17.	0.71
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.04


Closed Top
Acid Lining
Gas Take-Off
Afterburner
Charging Door Open
No Fuel Injection
No O_2 Enrichment
Hot Blast Air
Molten Iron
Slag

CUPOLA CLASSIFICATION - 28

Insufficient Data for
Heat and Material
Balance Calculations


Closed Top
Acid Lining
No Afterburner
Charging Door Open
Gas Take-Off
Hot Blast Air
No Fuel Injection With O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 29

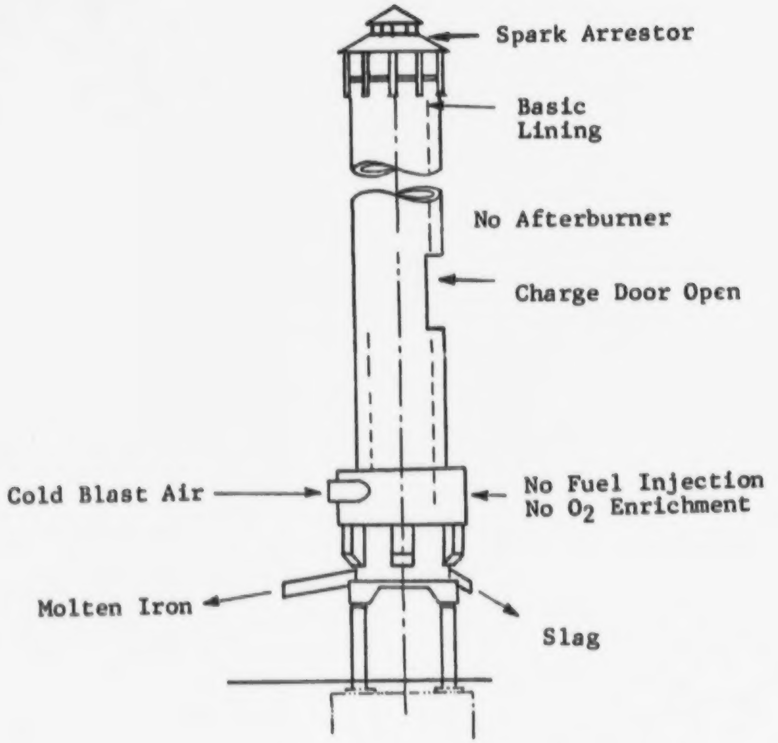
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
POTENTIAL HEAT OF FUEL	23751.	92.57
SENSIBLE HEAT OF THE BLAST	37.	0.15
HEAT FROM OXIDATION OF MN, FE, SI	1870.	7.29
TOTAL INPUT HEAT	25658.	100.00
OUTPUT HEAT		
HEATING AND MELTING OF IRON	8323.	32.44
HEAT CONTENT OF THE SLAG	588.	2.29
CALCINING OF LIMESTONE	547.	2.13
DECOMPOSITION OF WATER	327.	1.28
TOP GASES		
-SENSIBLE HEAT	3468.	13.52
-LATENT HEAT	8626.	33.62
HEAT RADIATION FROM THE CUPOLA	3779.	14.73

VOLUME OF TOP GAS (MCF)
ACTUAL 547.
STANDARD 217.

MATERIAL BALANCE

INPUTS	POUNDS	PERCENT
METAL CHARGE	2030.	45.69
PIG IRON	256.	5.77
RETURNS	1506.	33.90
STEEL SCRAP	0.	0.00
IRON SCRAP	223.	5.02
FERROALLOYS	45.	1.00
COKE	247.	5.56
NATURAL GAS	0.	0.00
FUEL OIL	0.	0.00
FLUX AND ADDITIVES	102.	2.29
AIR	2028.	45.66
OXYGEN	0.	0.00
CUPOLA LINING	36.	0.80
TOTAL INPUT MTLS	4443.	100.00
OUTPUTS		
MOLTEN IRON	2000.	45.02
SLAG	137.	3.09
EMISSIONS DUST	19.	0.42
TOP GASES	2286.	51.47
NITROGEN	1549.	67.74
CARBON DIOXIDE	470.	20.55
CARBON MONOXIDE	265.	11.57
HYDROGEN	2.	0.07
SULFUR DIOXIDE	1.	0.06


Spark Arrestor
Basic Lining
No Afterburner
Charge Door Open
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 30

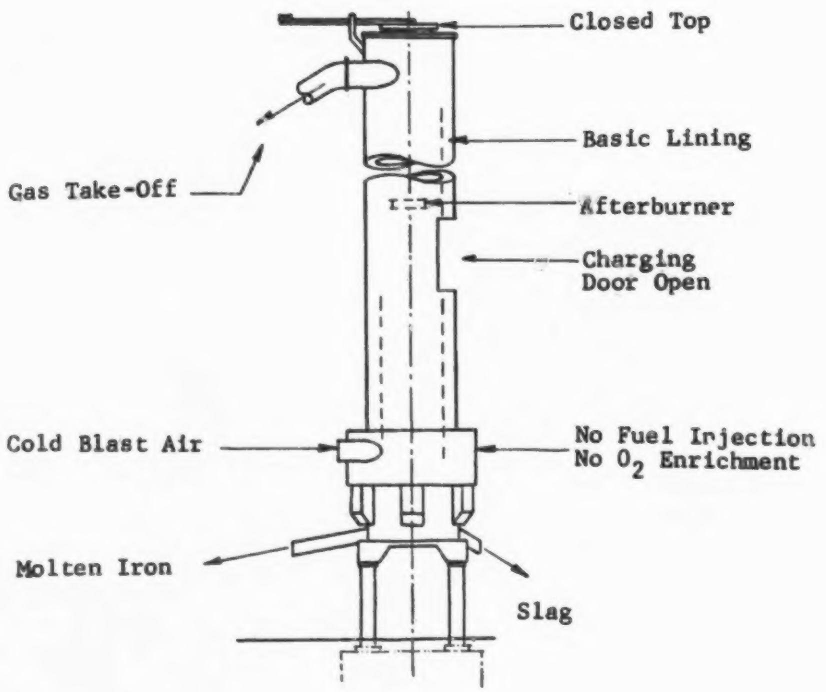
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	39465.	98.70
SENSIBLE HEAT ØF THE BLAST	56.	0.14
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	462.	1.16
TØTAL INPUT HEAT	39984.	100.00
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	12686.	31.73
HEAT CØNTENT ØF THE SLAG	413.	1.03
CALCINING ØF LIMESTØNE	474.	1.18
DECØMPØSITIØN ØF WATER	496.	1.24
TØP GASES		
-SENSIBLE HEAT	11694.	29.25
-LATENT HEAT	16365.	40.93
HEAT RADIATIØN FRØM THE CUPØLA	-2144.	-5.36

VØLUME ØF TØP GAS (MCF)
ACTUAL 1455.
STANDARD 335.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	2009.	45.30
PIG IRØN	0.	0.00
RETURNS	753.	16.99
STEEL SCRAP	151.	3.40
IRØN SCRAP	1105.	24.91
FERRØALLØYS	0.	0.00
CØKE	286.	6.44
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	58.	1.31
AIR	2058.	46.40
ØXYGEN	0.	0.00
CUPØLA LINING	24.	0.55
TØTAL INPUT MTLS	4436.	100.00
ØUTPUTS		
MØLTEN IRØN	2000.	45.09
SLAG	75.	1.69
EMISSIØNS DUST	20.	0.46
TØP GASES	2340.	52.77
NITRØGEN	1571.	67.14
CARBØN DIØXIDE	430.	18.35
CARBØN MØNØXIDE	336.	14.37
HYDRØGEN	2.	0.07
SULFUR DIØXIDE	2.	0.07


Closed Top
Basic Lining
Gas Take-Off
Afterburner
Charging Door Open
Cold Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

CUPOLA CLASSIFICATION - 31

APPENDIX C
EXHIBIT 3

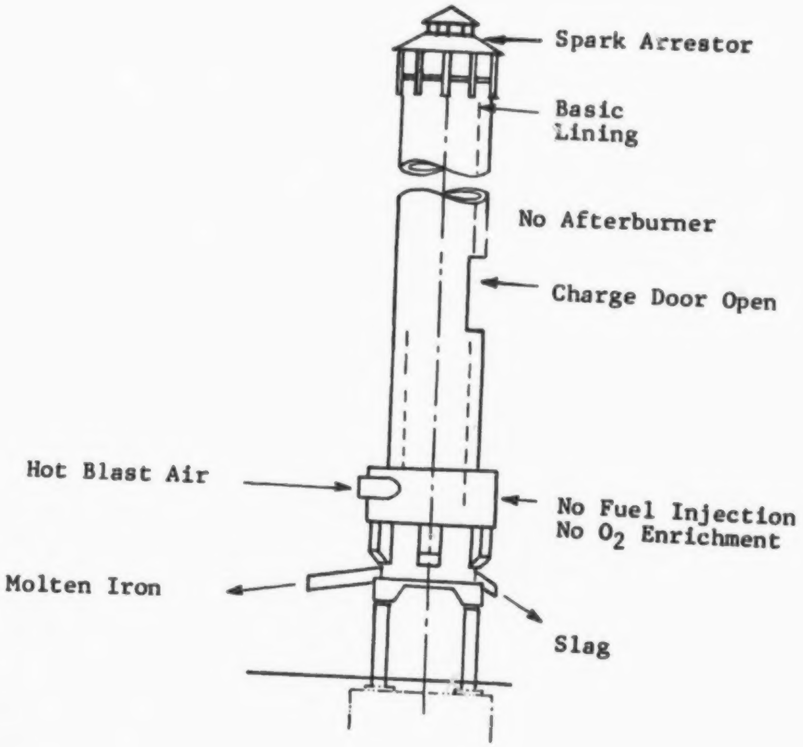
HEAT BALANCE

INPUT HEAT	B.T.U.S (000/HR.)	PERCENT
PØTENTIAL HEAT ØF FUEL	79902.	77.46
SENSIBLE HEAT ØF THE BLAST	21611.	20.95
HEAT FRØM ØXIDATIØN ØF MN, FE, SI	1634.	1.58
TØTAL INPUT HEAT	103147.	100.00
ØUTPUT HEAT		
HEATING AND MELTING ØF IRØN	40009.	38.79
HEAT CØNTENT ØF THE SLAG	617.	0.60
CALCINING ØF LIMESTØNE	2347.	2.28
DECØMPØSITIØN ØF WATER	1473.	1.43
TØP GASES		
-SENSIBLE HEAT	25238.	24.47
-LATENT HEAT	-93602.	-90.75
HEAT RADIATIØN FRØM THE CUPØLA	127064.	123.19

VØLUME ØF TØP GAS (MCF)
ACTUAL 3651.
STANDARD 1449.

MATERIAL BALANCE

INPUTS	PØUNDS	PERCENT
METAL CHARGE	1963.	34.38
PIG IRØN	255.	4.46
RETURNS	255.	4.46
STEEL SCRAP	1454.	25.47
IRØN SCRAP	0.	0.00
FERRØALLØYS	0.	0.00
CØKE	235.	4.12
NATURAL GAS	0.	0.00
FUEL ØIL	0.	0.00
FLUX AND ADDITIVES	90.	1.58
AIR	3414.	59.78
ØXYGEN	0.	0.00
CUPØLA LINING	8.	0.14
TØTAL INPUT MTLS	5711.	100.00
ØUTPUTS		
MØLTEN IRØN	2000.	35.02
SLAG	64.	1.12
EMISSIØNS DUST	25.	0.44
TØP GASES	3622.	63.42
NITRØGEN	2615.	72.20
CARBØN DIØXIDE	1625.	44.86
CARBØN MØNØXIDE	-615.	-16.99
HYDRØGEN	2.	0.04
SULFUR DIØXIDE	-4.	-0.12


Spark Arrestor
Basic Lining
No Afterburner
Charge Door Open
Hot Blast Air
No Fuel Injection
No O_2 Enrichment
Molten Iron
Slag

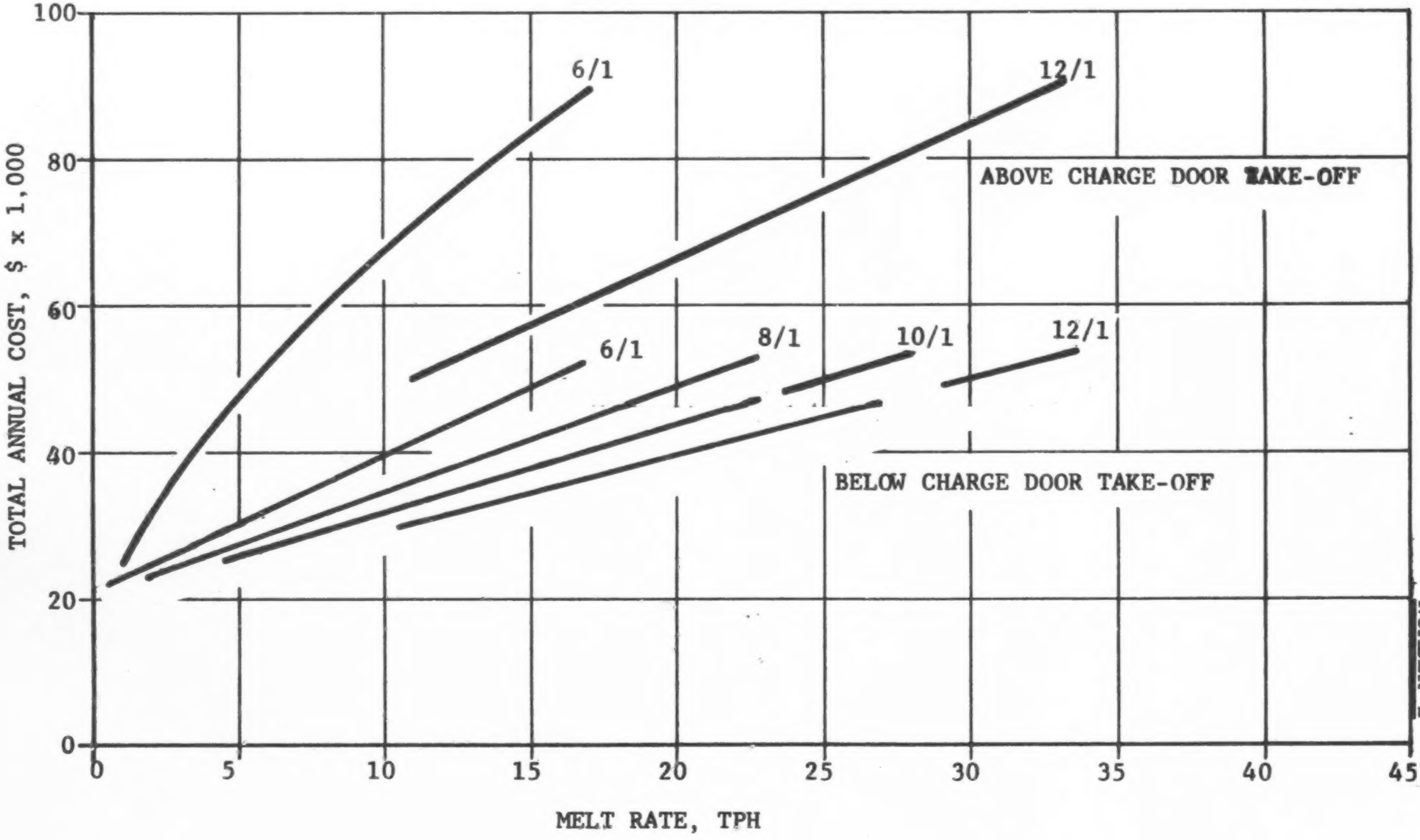
APPENDIX D

DETAIL ECONOMIC COST CURVES

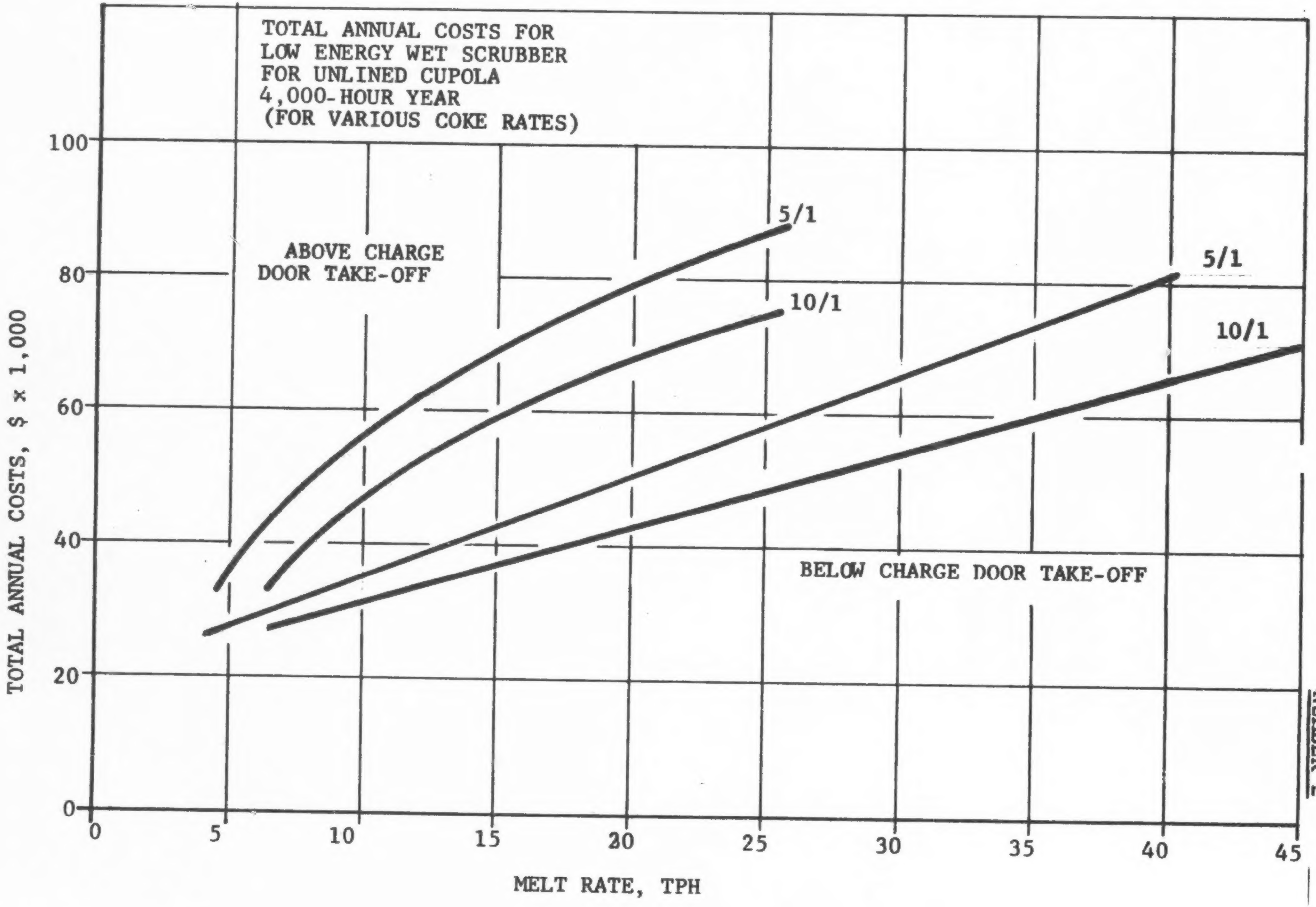
This appendix contains the detail curves used to determine the cost of pollution control equipment. Summaries of these curves appear as exhibits in Section VIII of the report.

Following the economic cost curves are the detail data for determining the melt shop costs for the model foundries.

TOTAL ANNUAL COSTS FOR LOW ENERGY WET SCRUBBER FOR LINED CUPOLA 4,000-HOUR YEAR (FOR VARIOUS COKE RATES)

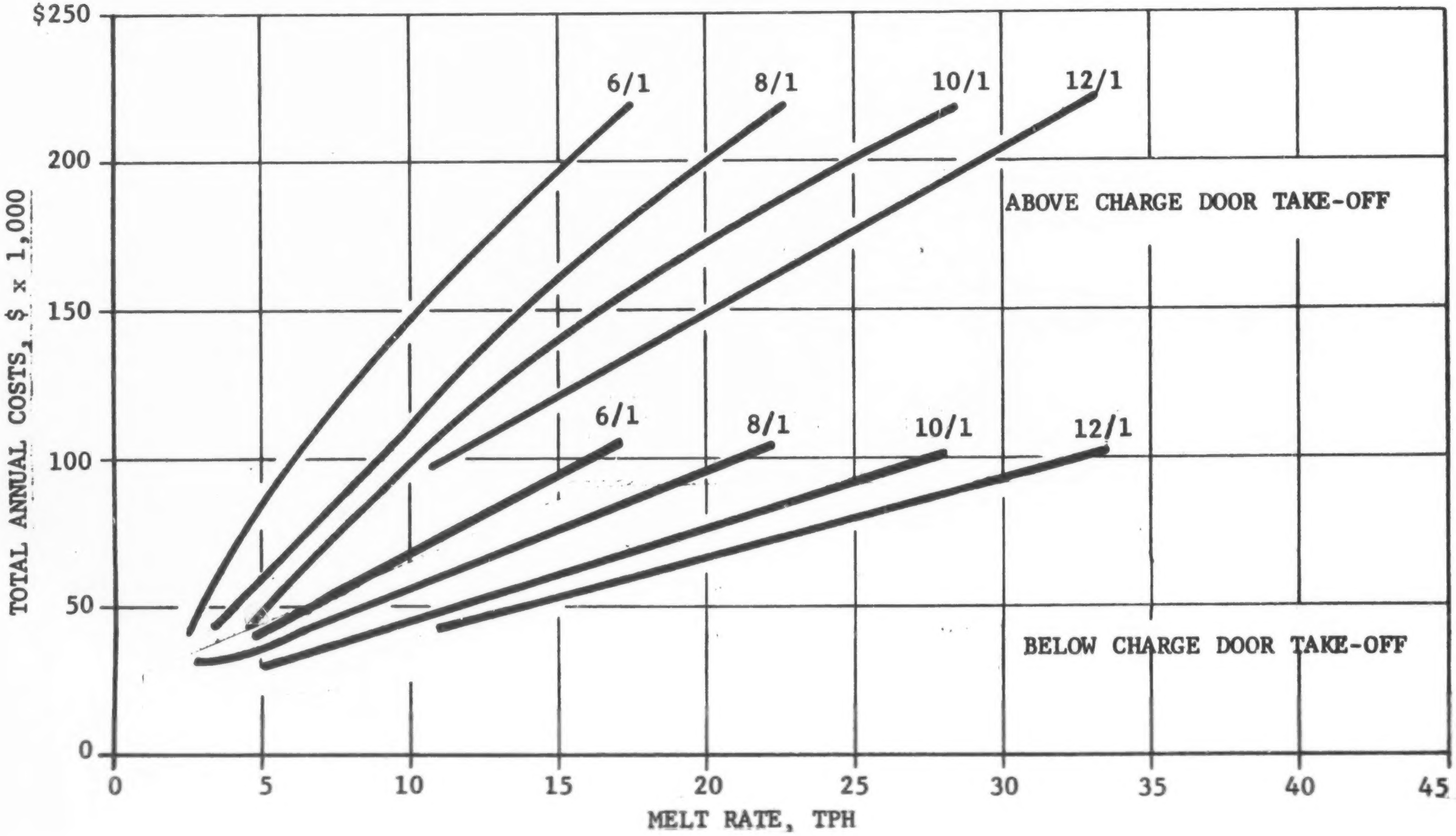


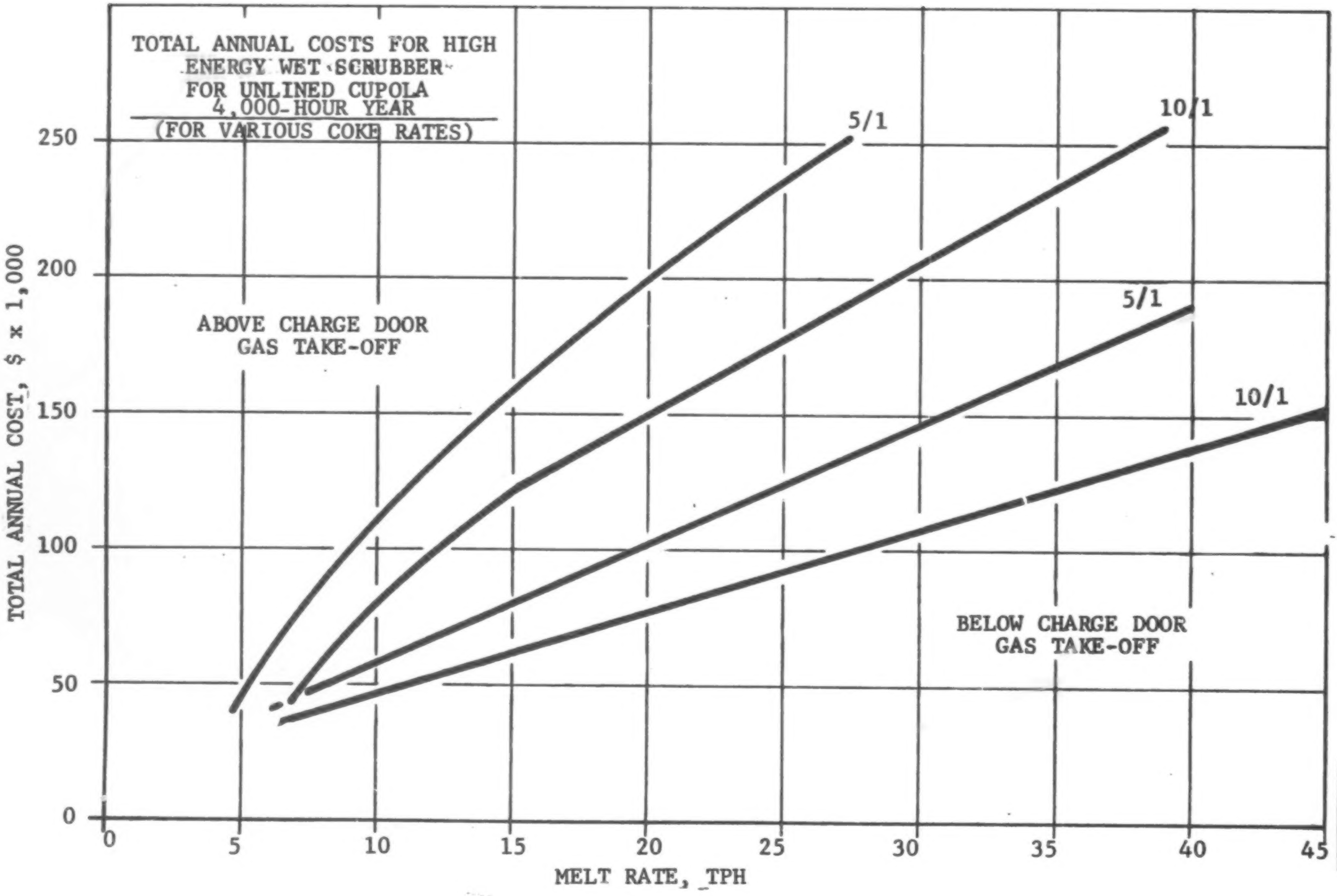
APPENDIX D
NUMBER 2

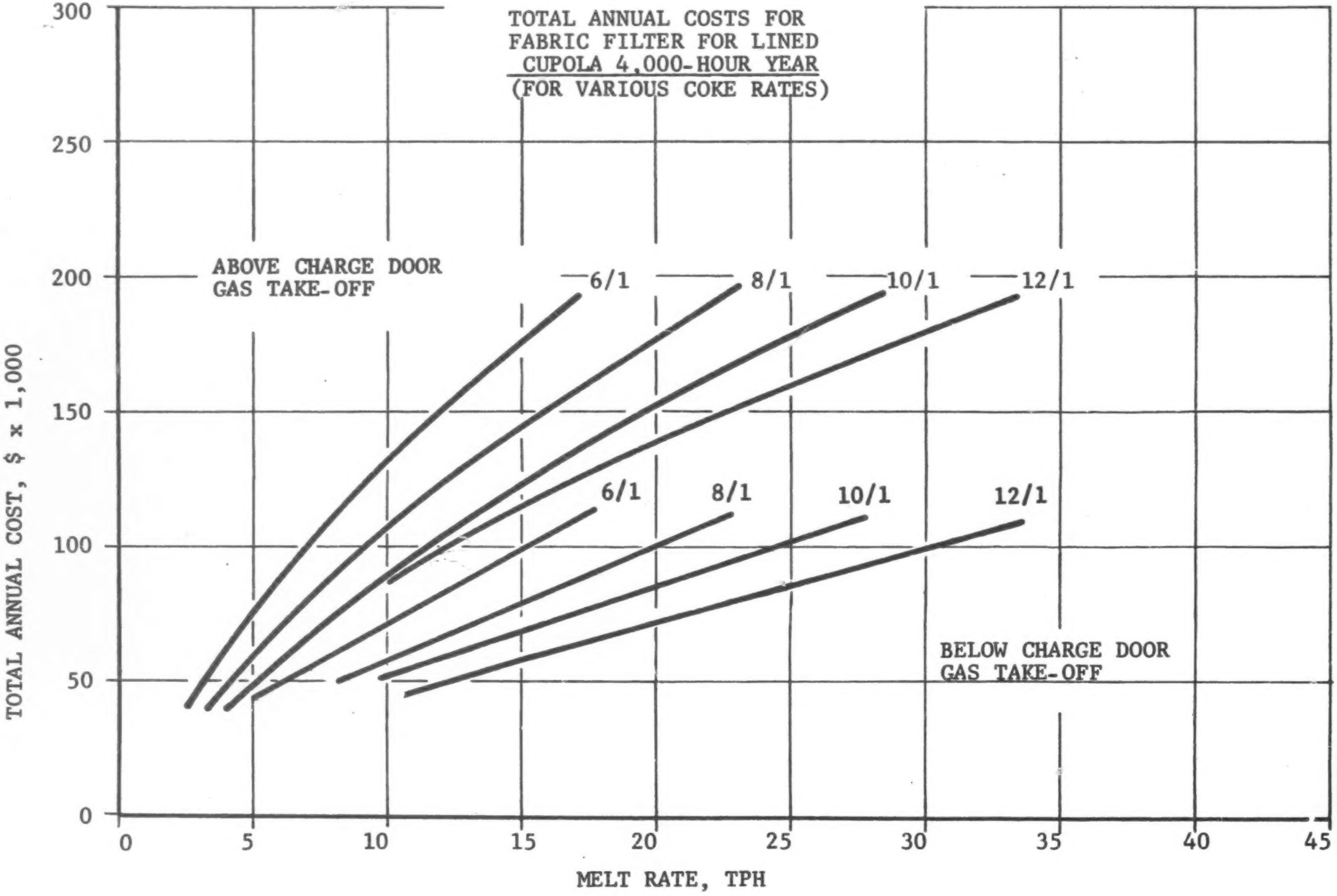


APPENDIX D
NUMBER 3

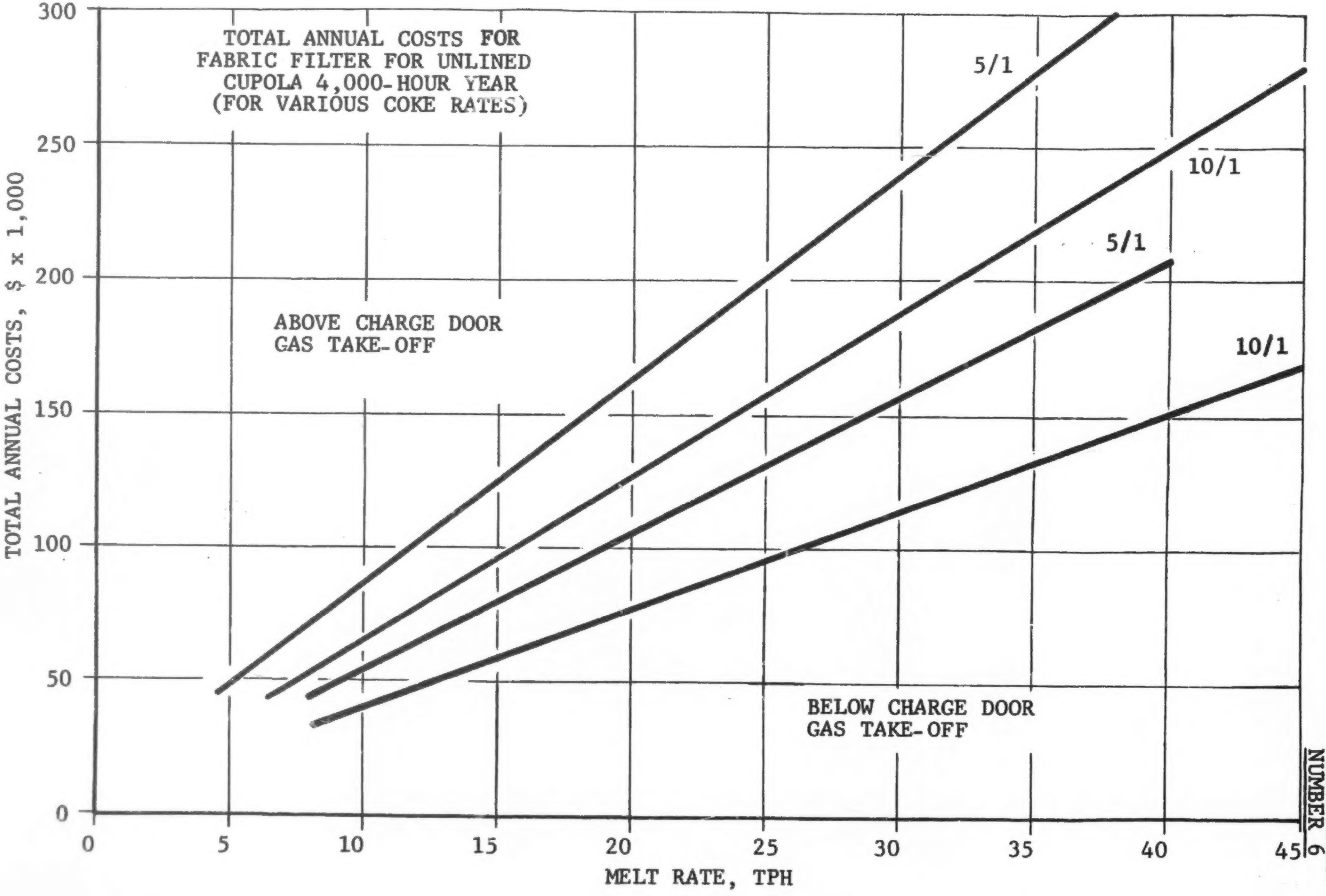
TOTAL ANNUAL COSTS FOR HIGH ENERGY
WET SCRUBBER FOR LINED CUPOLA
4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)




TOTAL ANNUAL COSTS FOR HIGH
ENERGY WET SCRUBBER
FOR UNLINED CUPOLA
4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)
ABOVE CHARGE DOOR
GAS TAKE-OFF
BELOW CHARGE DOOR
GAS TAKE-OFF
5/1
10/1
5/1
10/1
TOTAL ANNUAL COST, $ x 1,000
0
50
100
150
200
250
MELT RATE, TPH
0
5
10
15
20
25
30
35
40
45



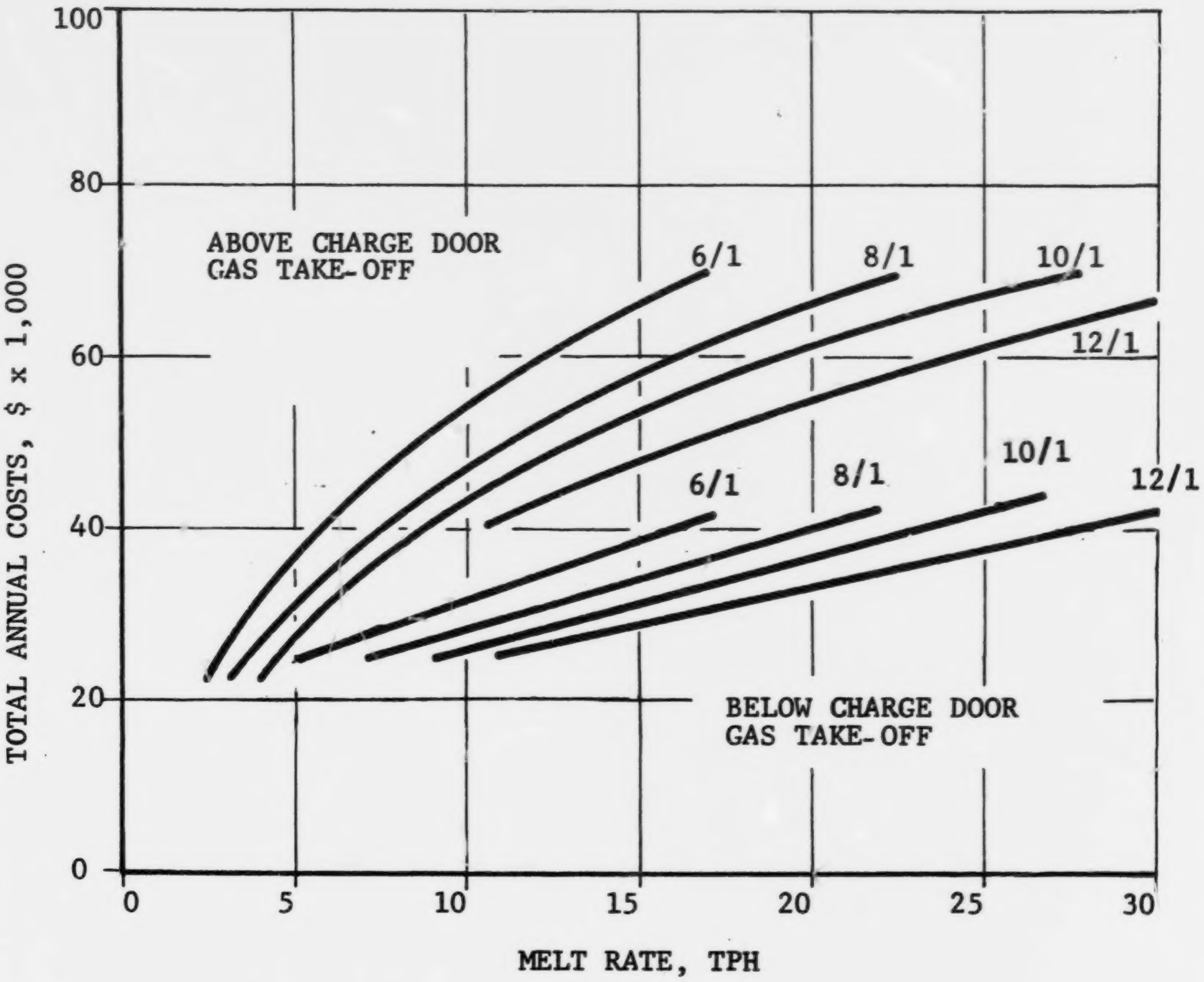
TOTAL ANNUAL COSTS FOR
FABRIC FILTER FOR LINED
CUPOLA 4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



TOTAL ANNUAL COSTS FOR FABRIC FILTER FOR UNLINED CUPOLA 4,000-HOUR YEAR (FOR VARIOUS COKE RATES)

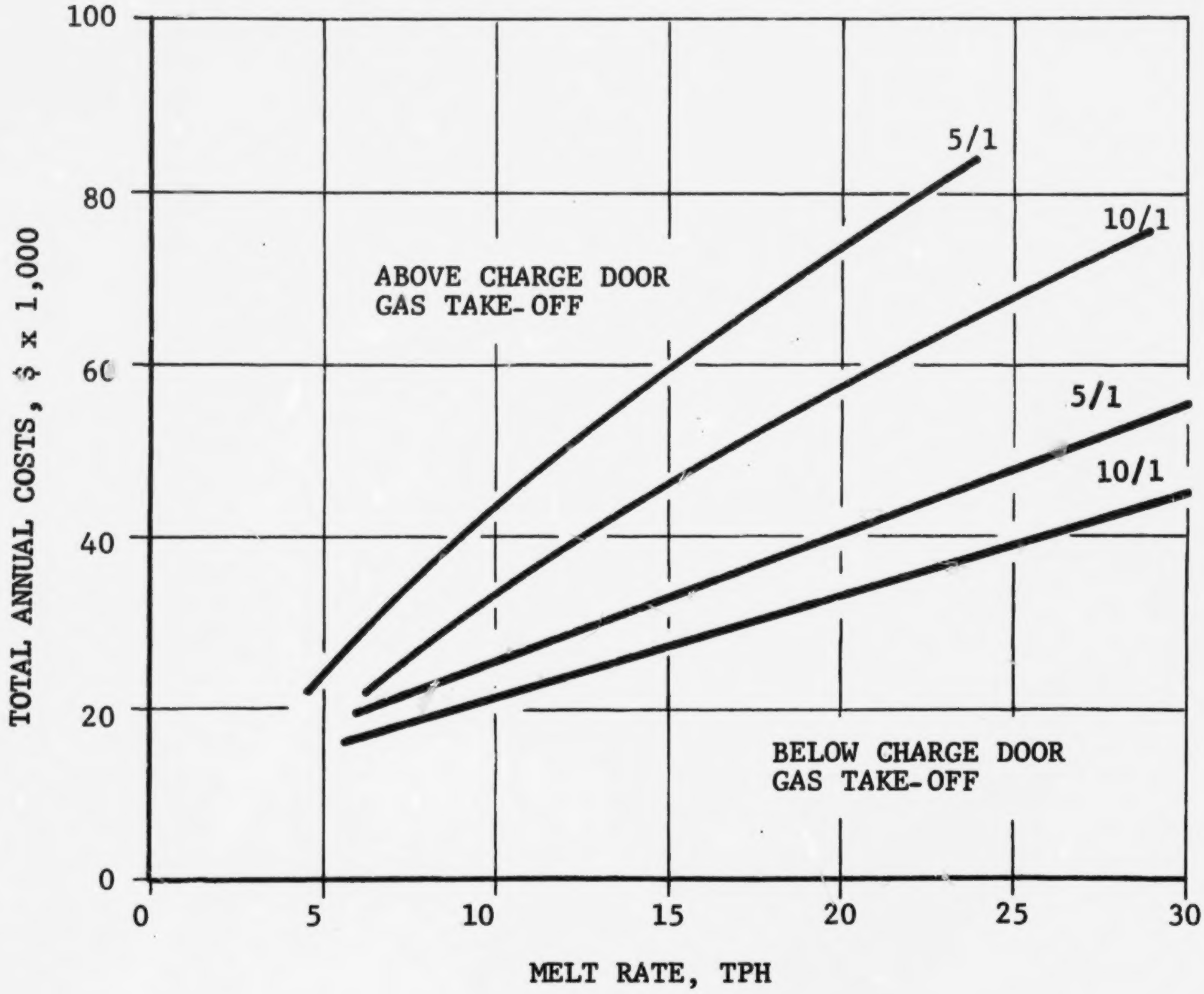
TOTAL ANNUAL COSTS FOR LOW ENERGY WET SCRUBBER ON LINED CUPOLA 2,000-HOUR YEAR

(FOR VARIOUS COKE RATES)

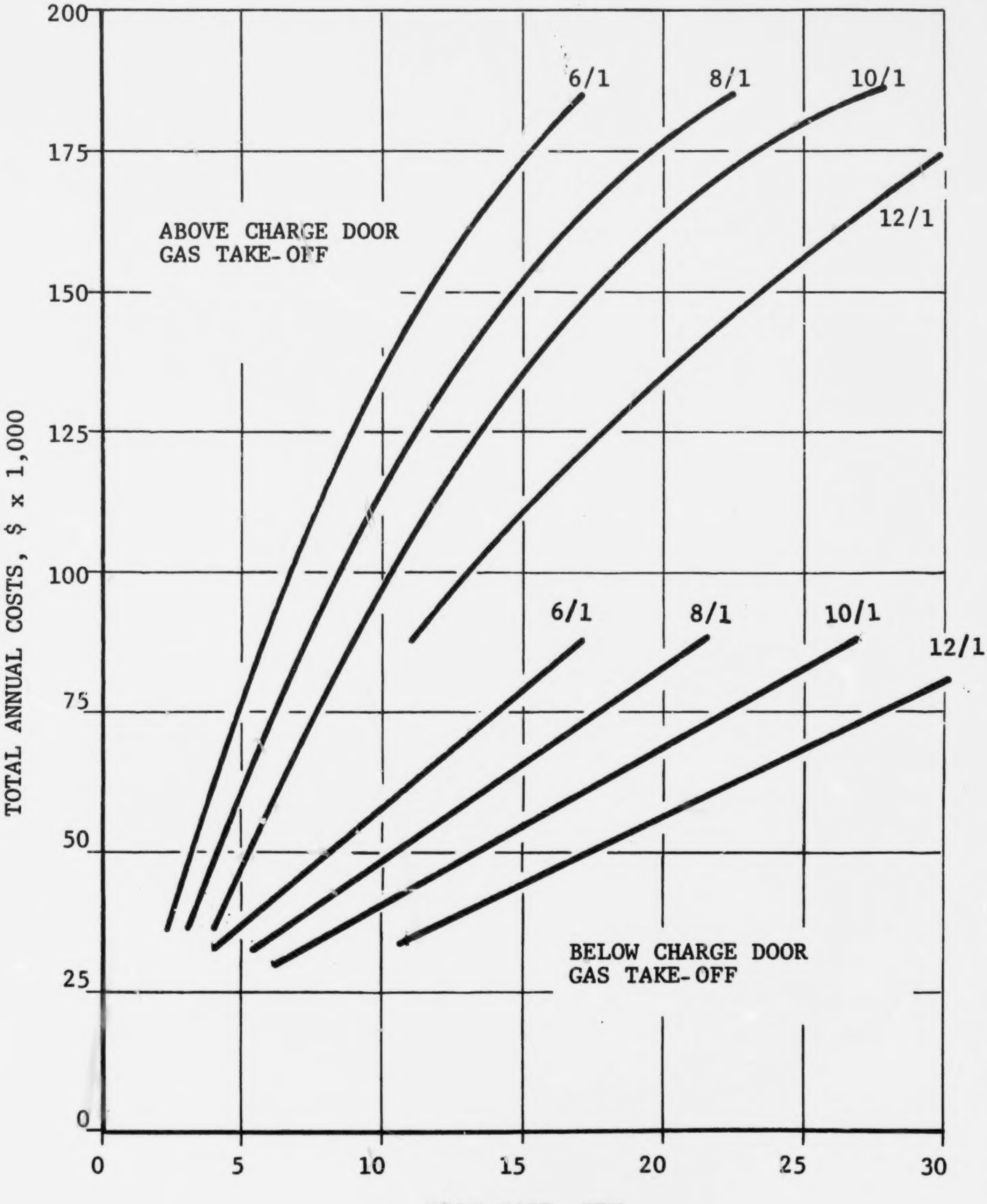


APPENDIX D
NUMBER 8

TOTAL ANNUAL COSTS FOR
LOW ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

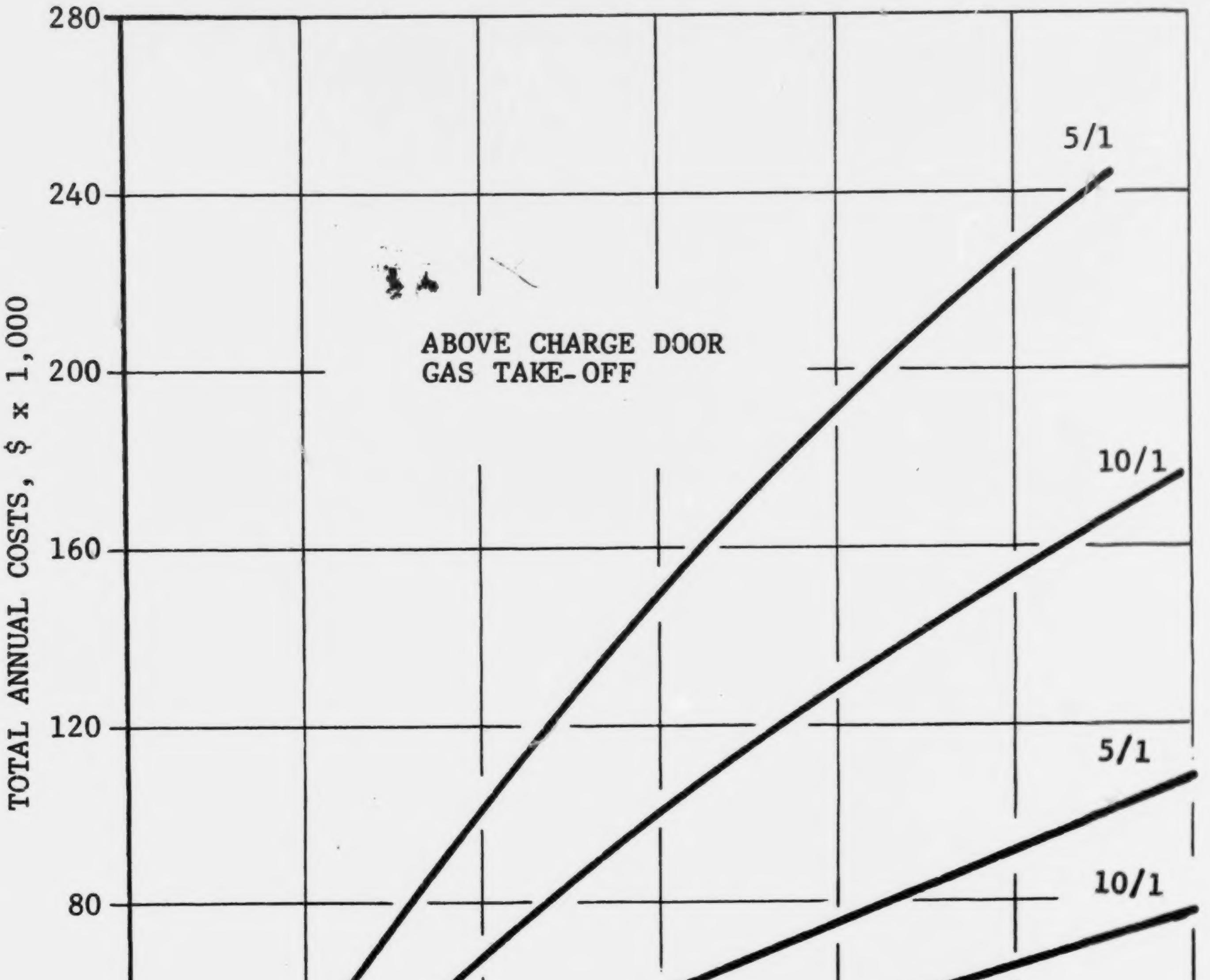


TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON LINED CUPOLA 2,000-HOUR YEAR (FOR VARIOUS COKE RATES)

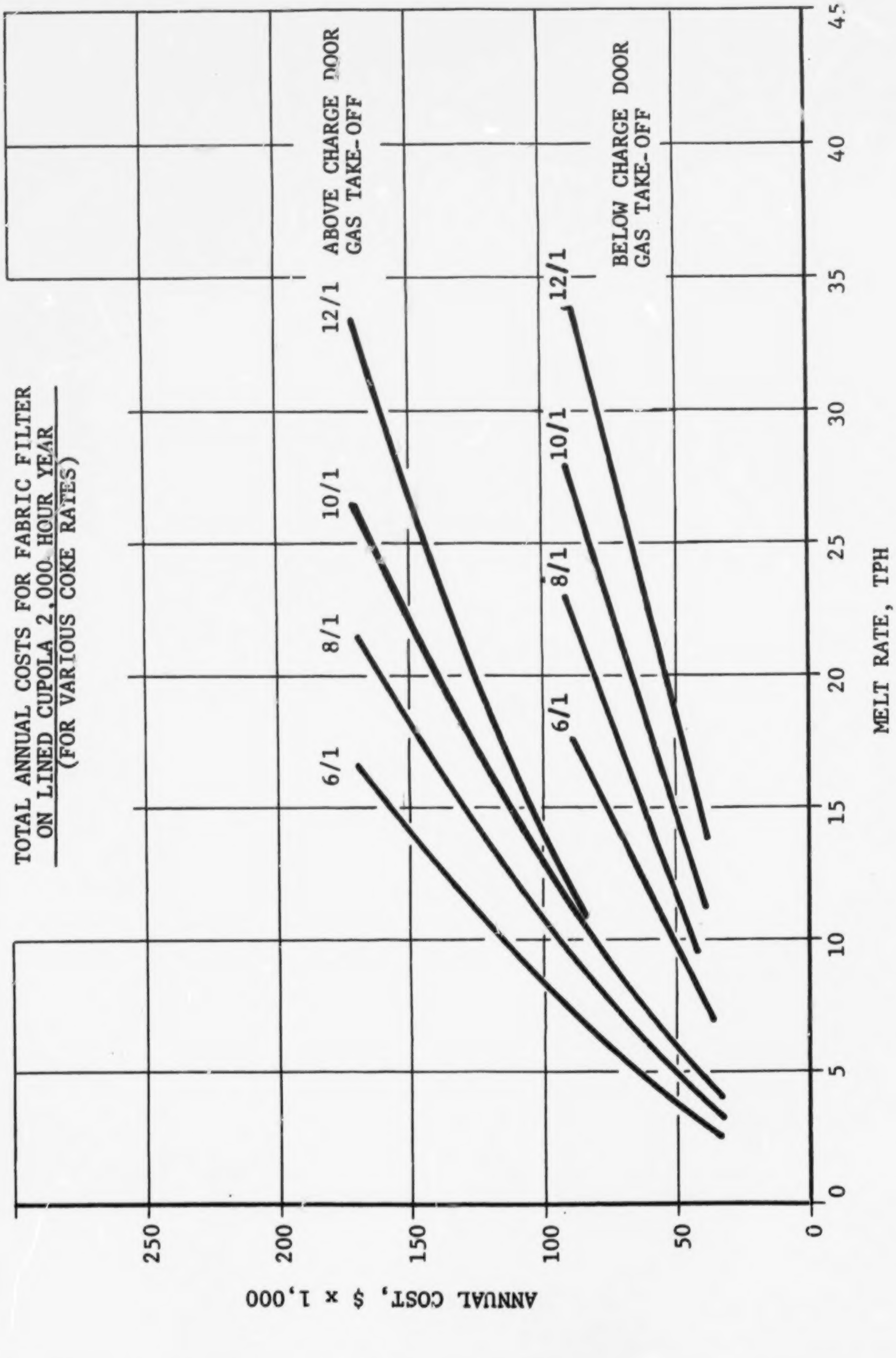


APPENDIX D
NUMBER 10

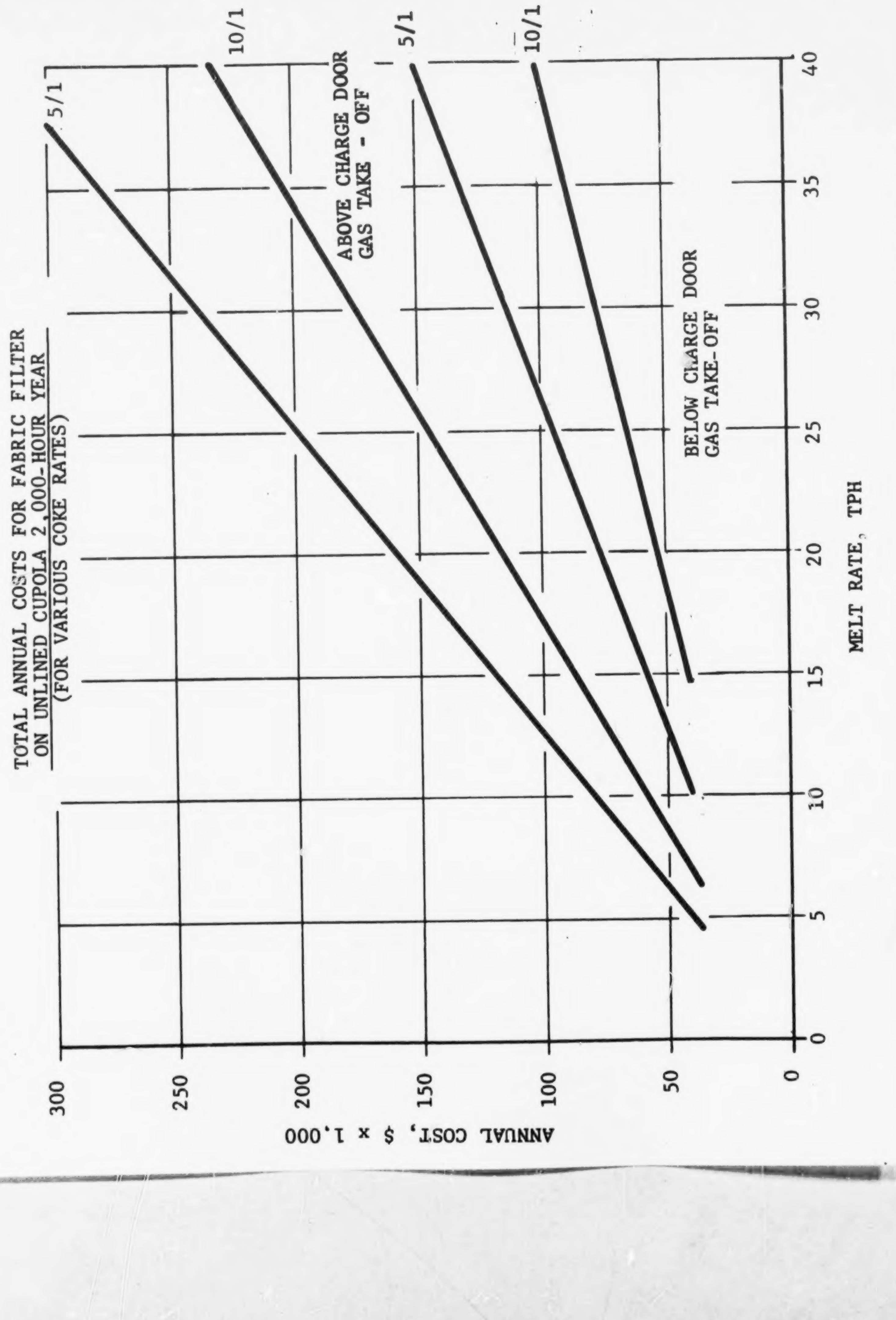
TOTAL ANNUAL COSTS FOR
HIGH ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



APPENDIX D
NUMBER 11

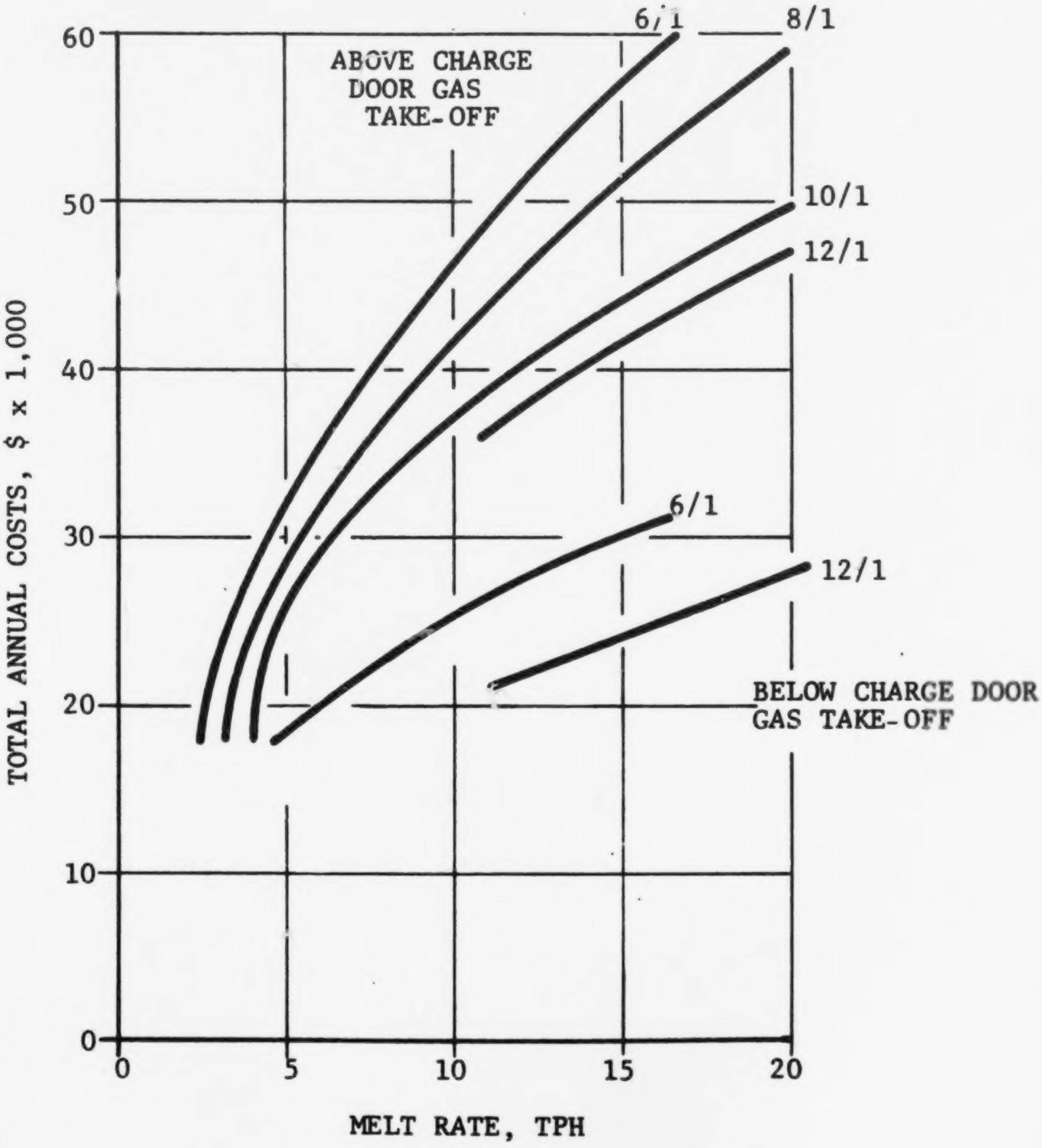


TOTAL ANNUAL COSTS FOR FABRIC FILTER
ON LINED CUPOLA 2,000 HOUR YEAR
(FOR VARIOUS COKE RATES)

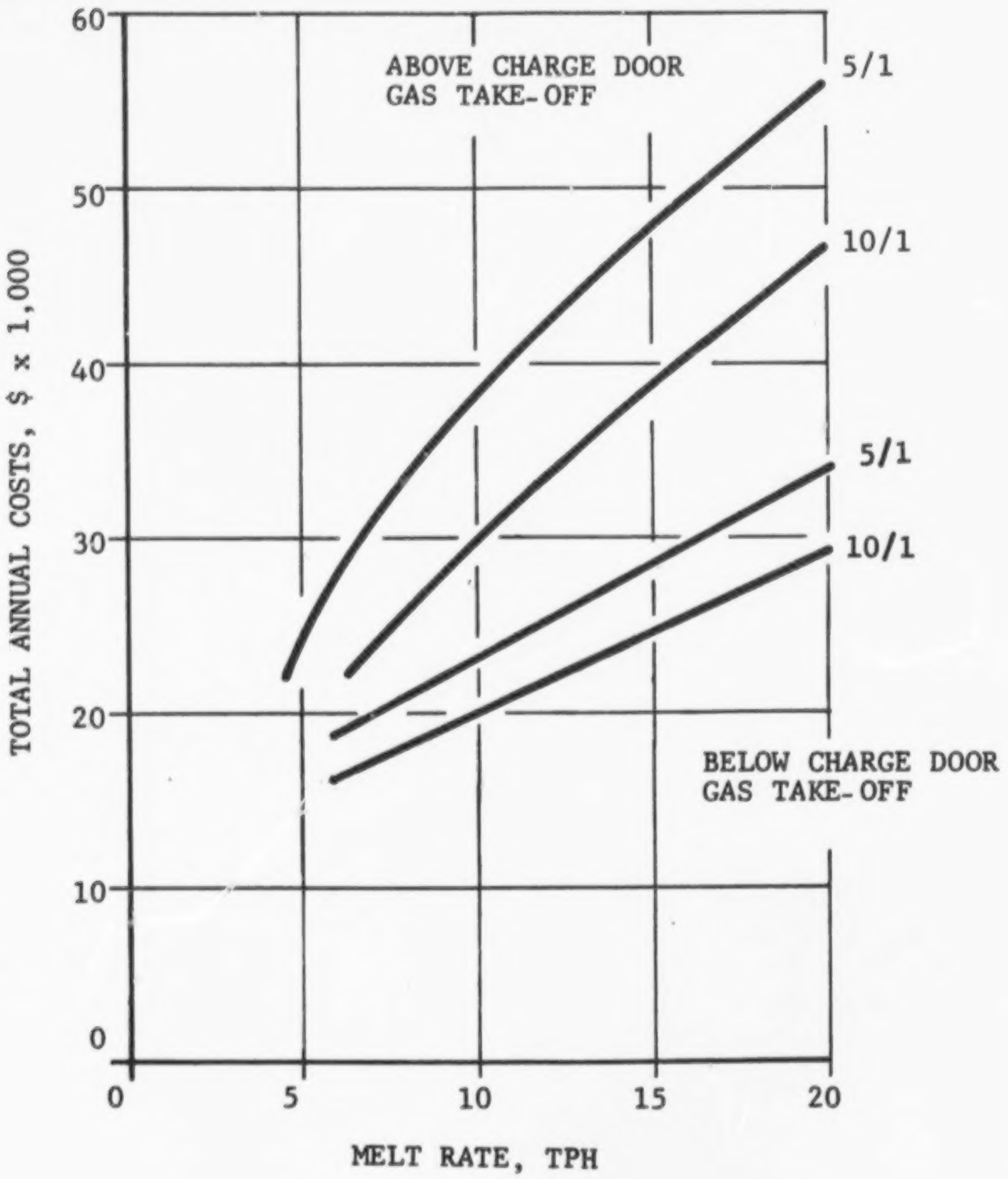


TOTAL ANNUAL COSTS FOR FABRIC FILTER
ON UNLINED CUPOLA 2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

TOTAL ANNUAL COSTS FOR LOW ENERGY WET SCRUBBER ON LINED CUPOLA 1,000-HOUR YEAR (FOR VARIOUS COKE RATES)



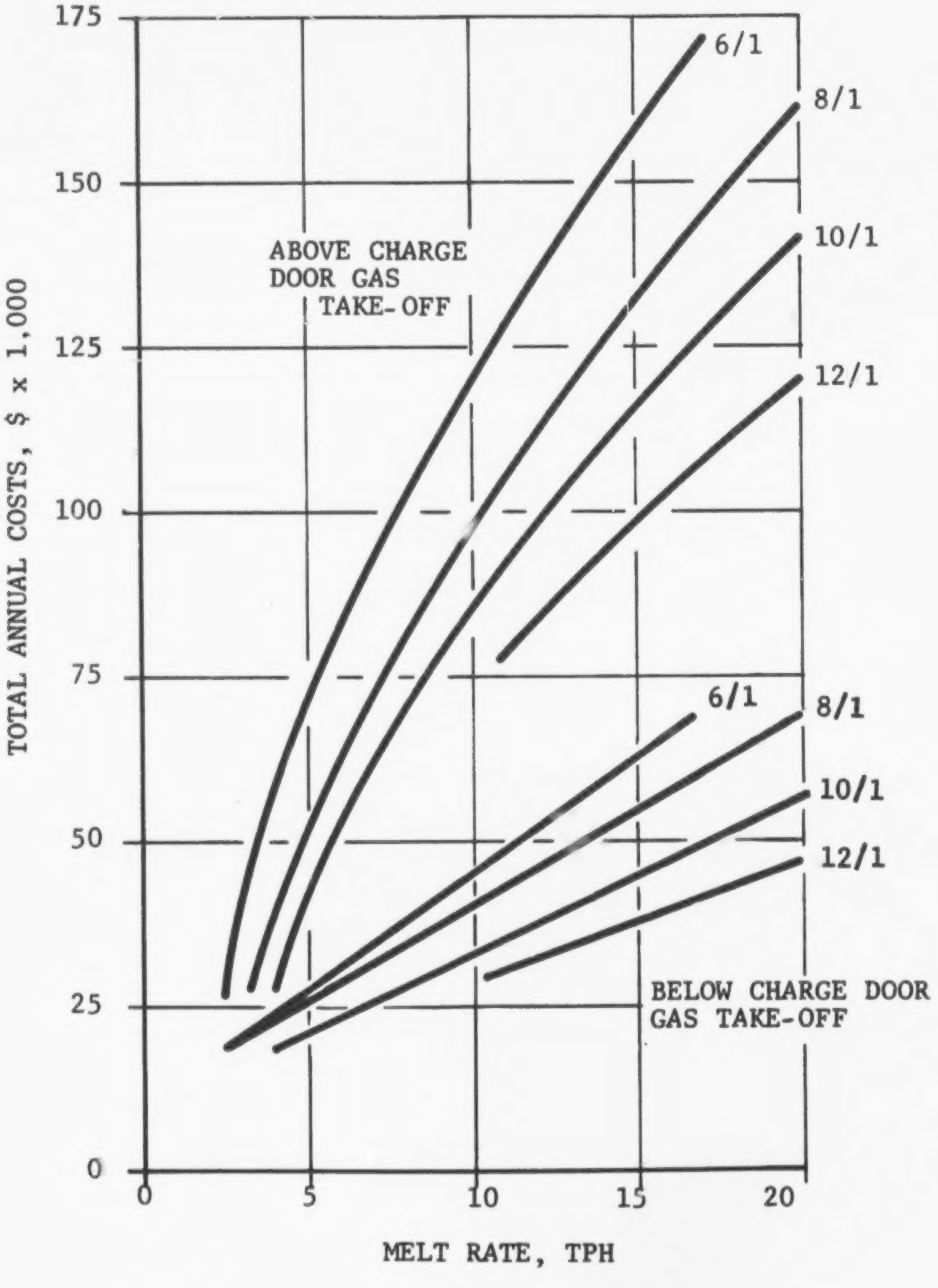
TOTAL ANNUAL COSTS FOR LOW ENERGY WET SCRUBBER ON UNLINED CUPOLA 1,000-HOUR YEAR (FOR VARIOUS COKE RATES)



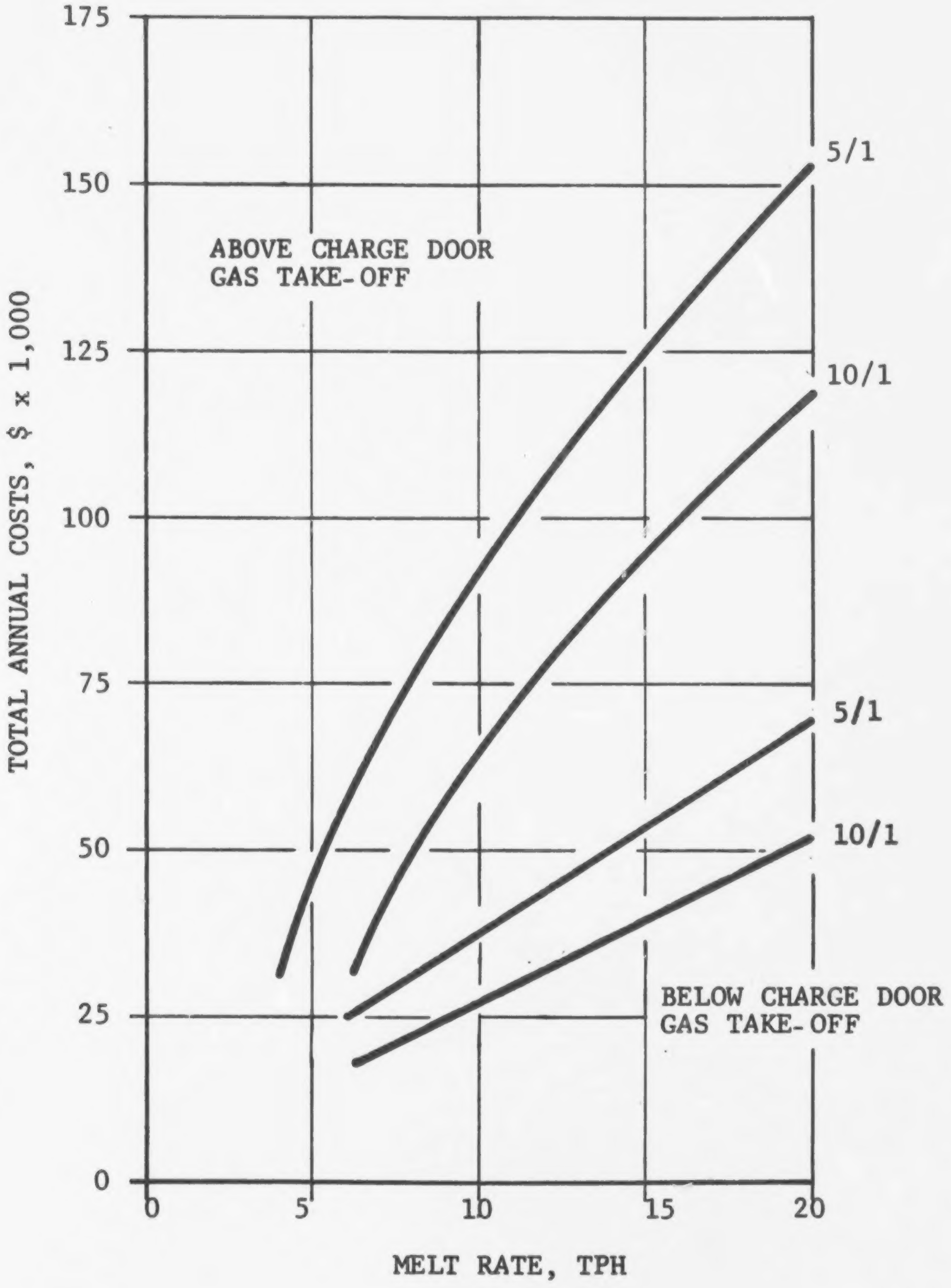
APPENDIX D
NUMBER 15

TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON LINED CUPOLA 1,000-HOUR YEAR

(FOR VARIOUS COKE RATES)

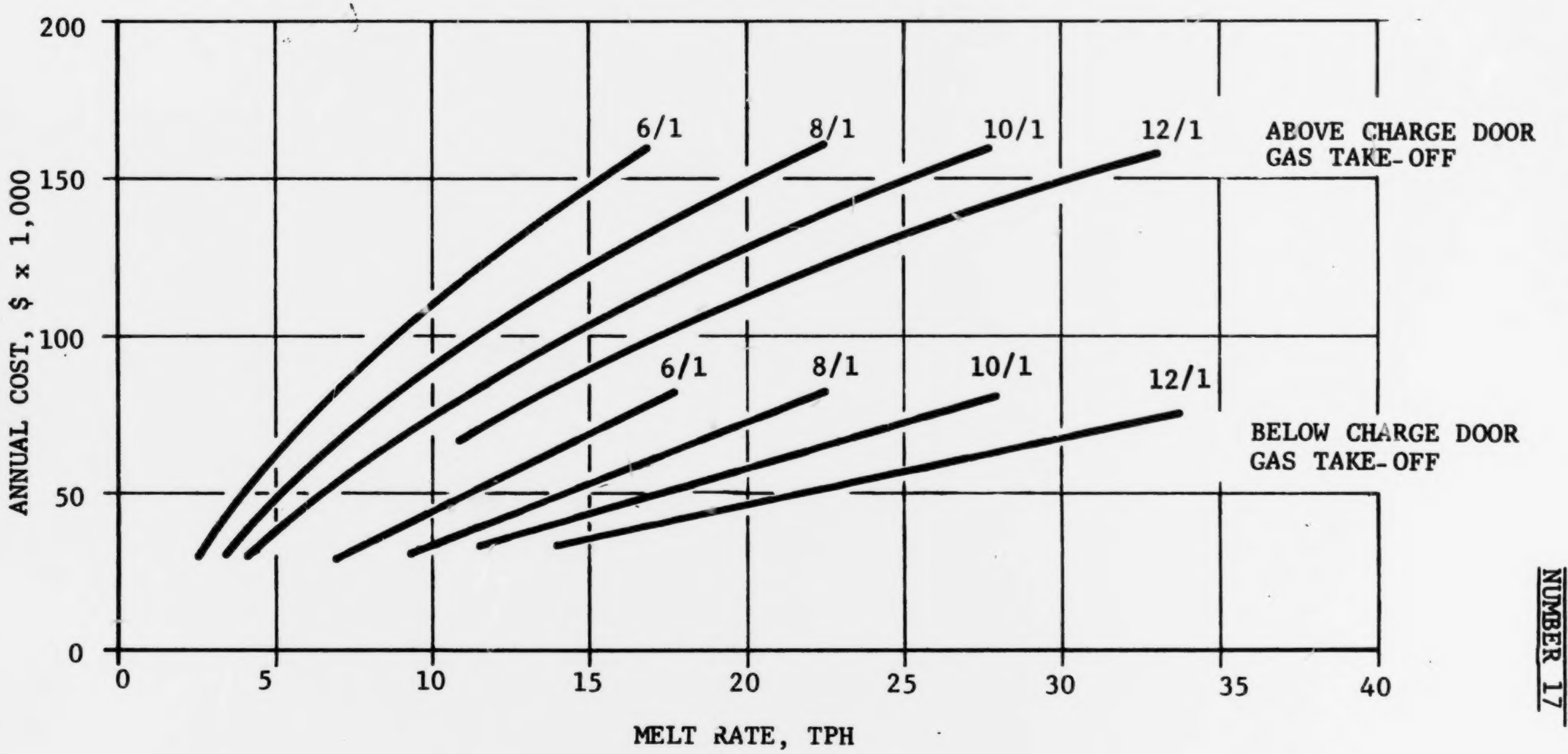


TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON UNLINED CUPOLA 1,000-HOUR YEAR (FOR VARIOUS COKE RATES)



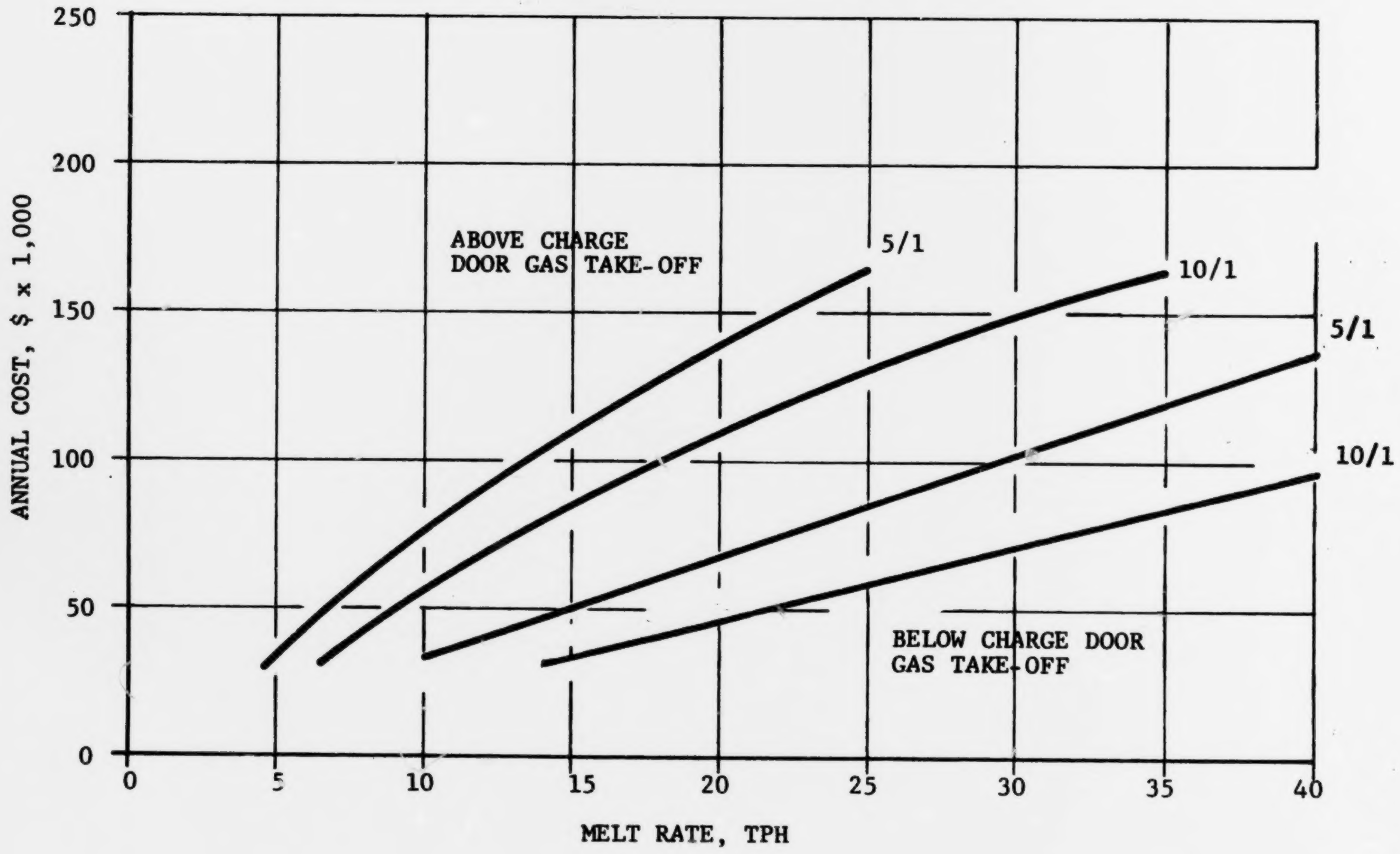
APPENDIX D
NUMBER 17

TOTAL ANNUAL COSTS FOR FABRIC FILTER ON LINED CUPOLA 1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

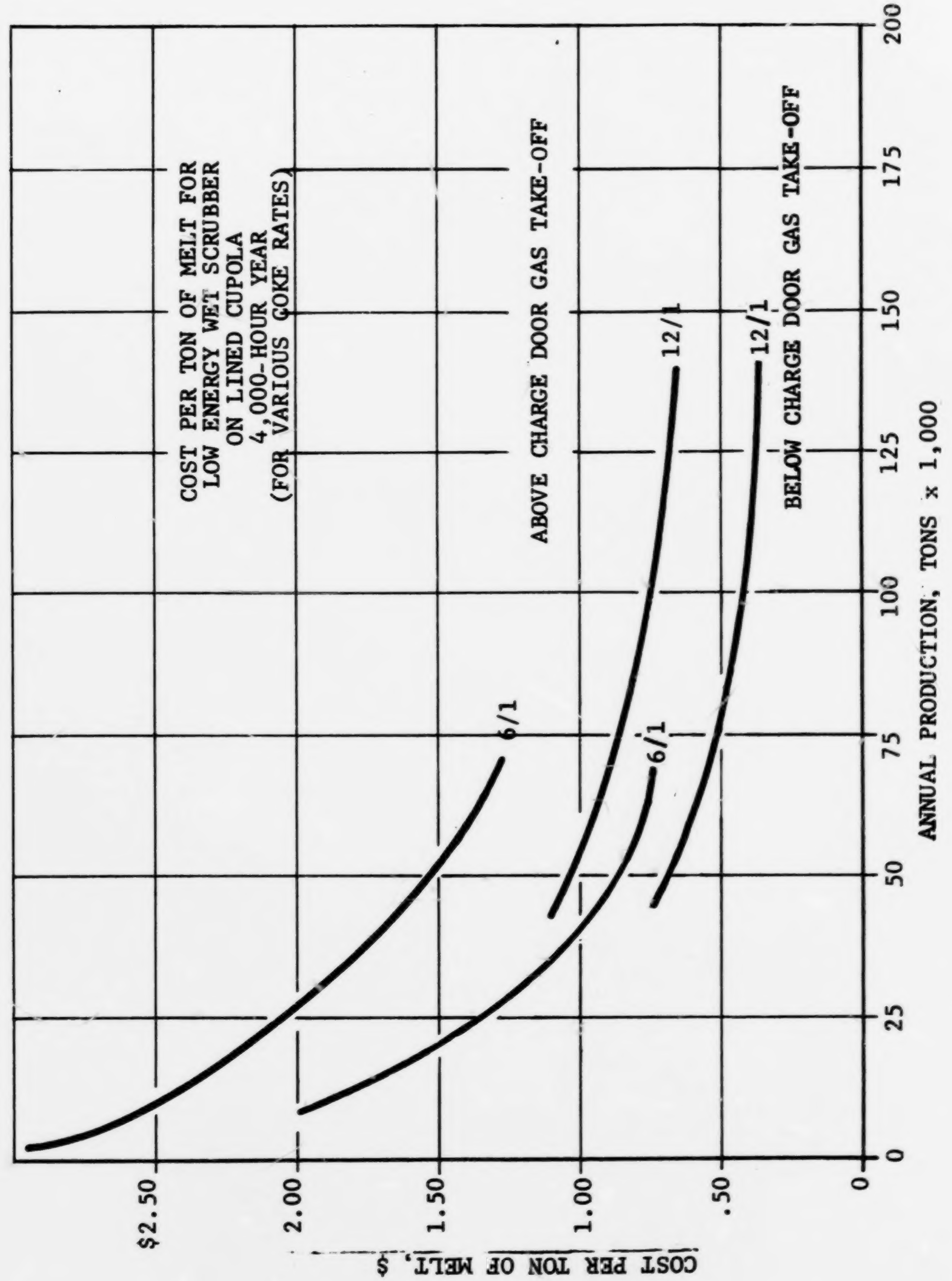


APPENDIX D
NUMBER 18

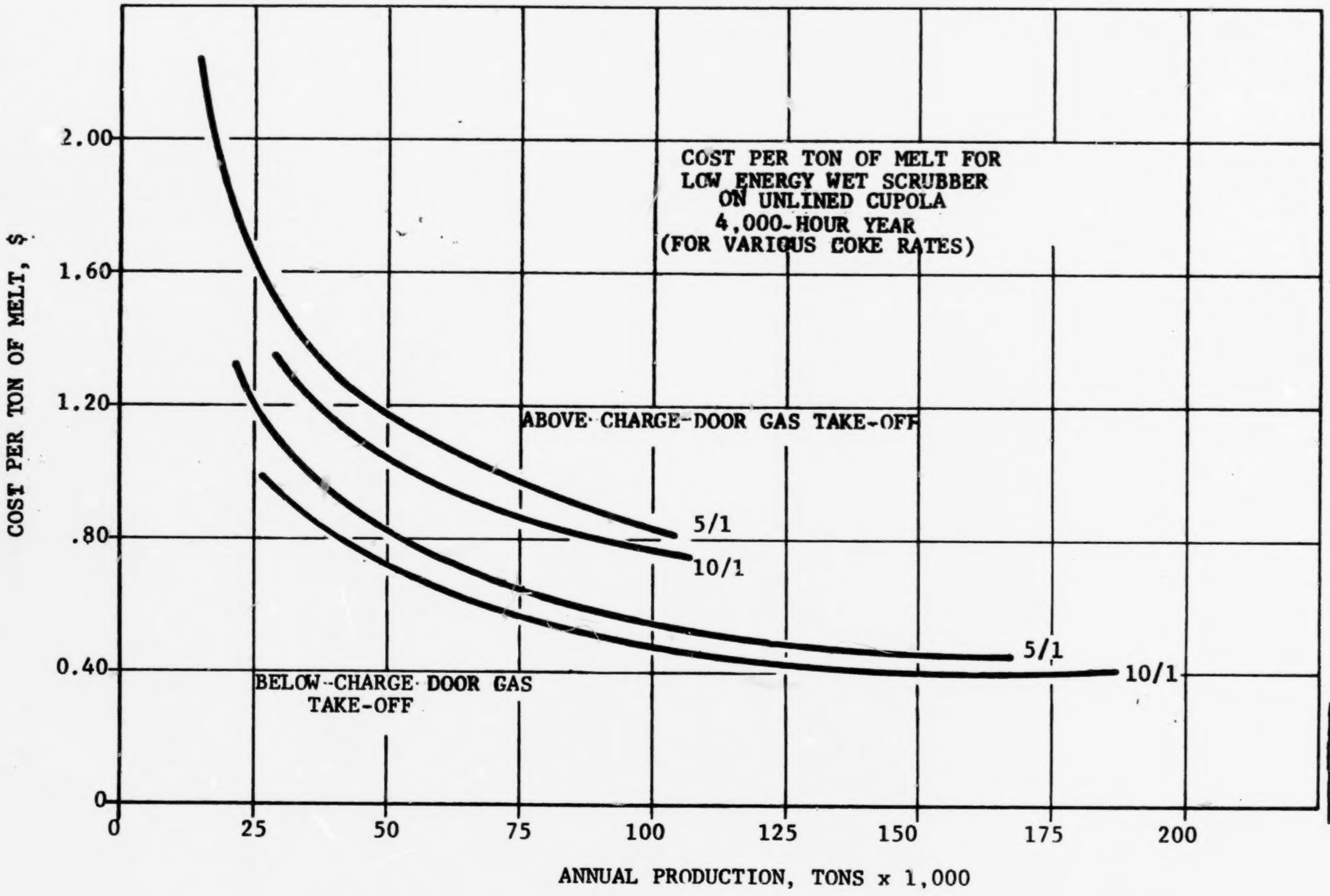
TOTAL ANNUAL COSTS FOR FABRIC FILTER
ON UNLINED CUPOLA 1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



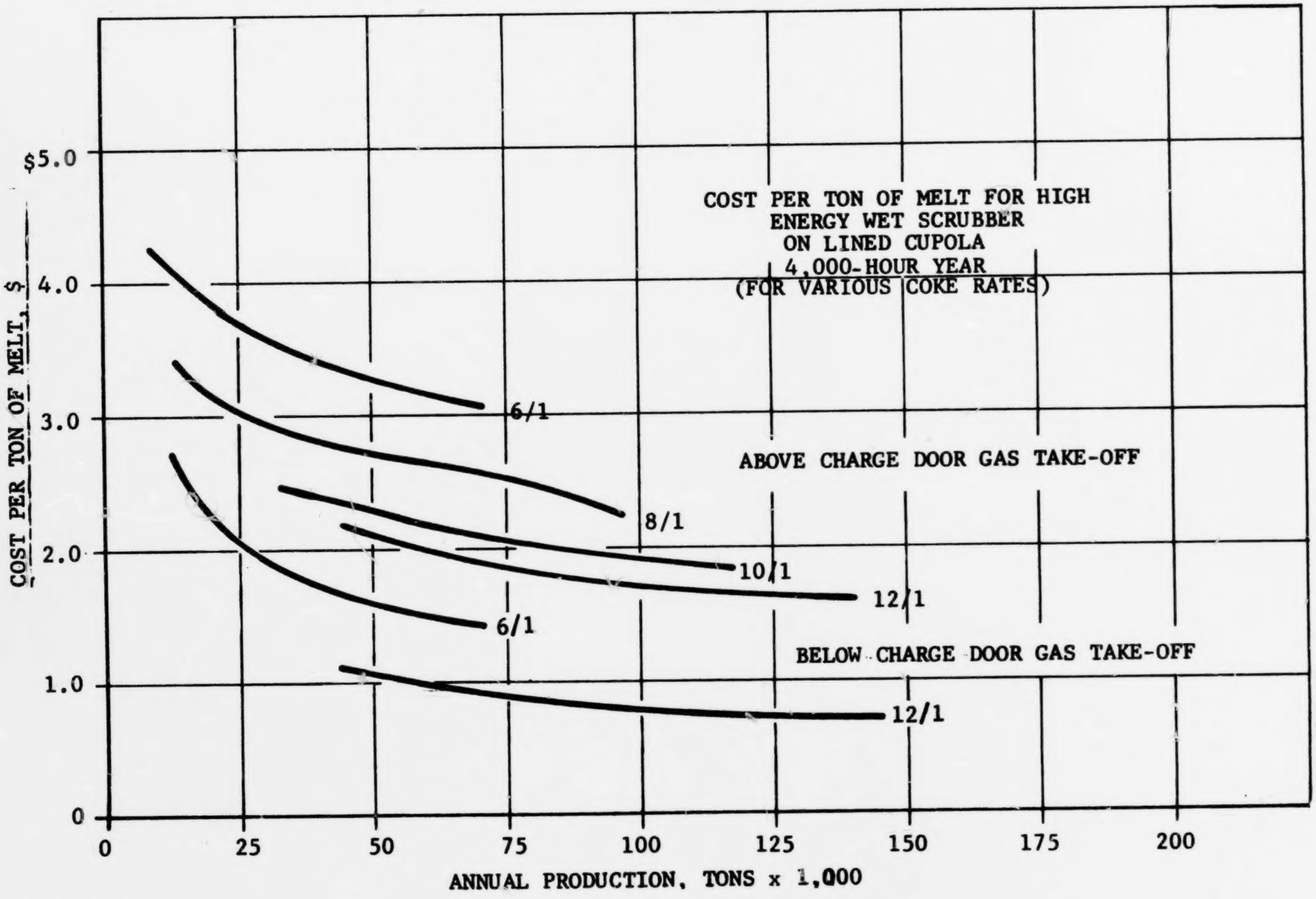
APPENDIX D
NUMBER 19



APPENDIX D
NUMBER 20

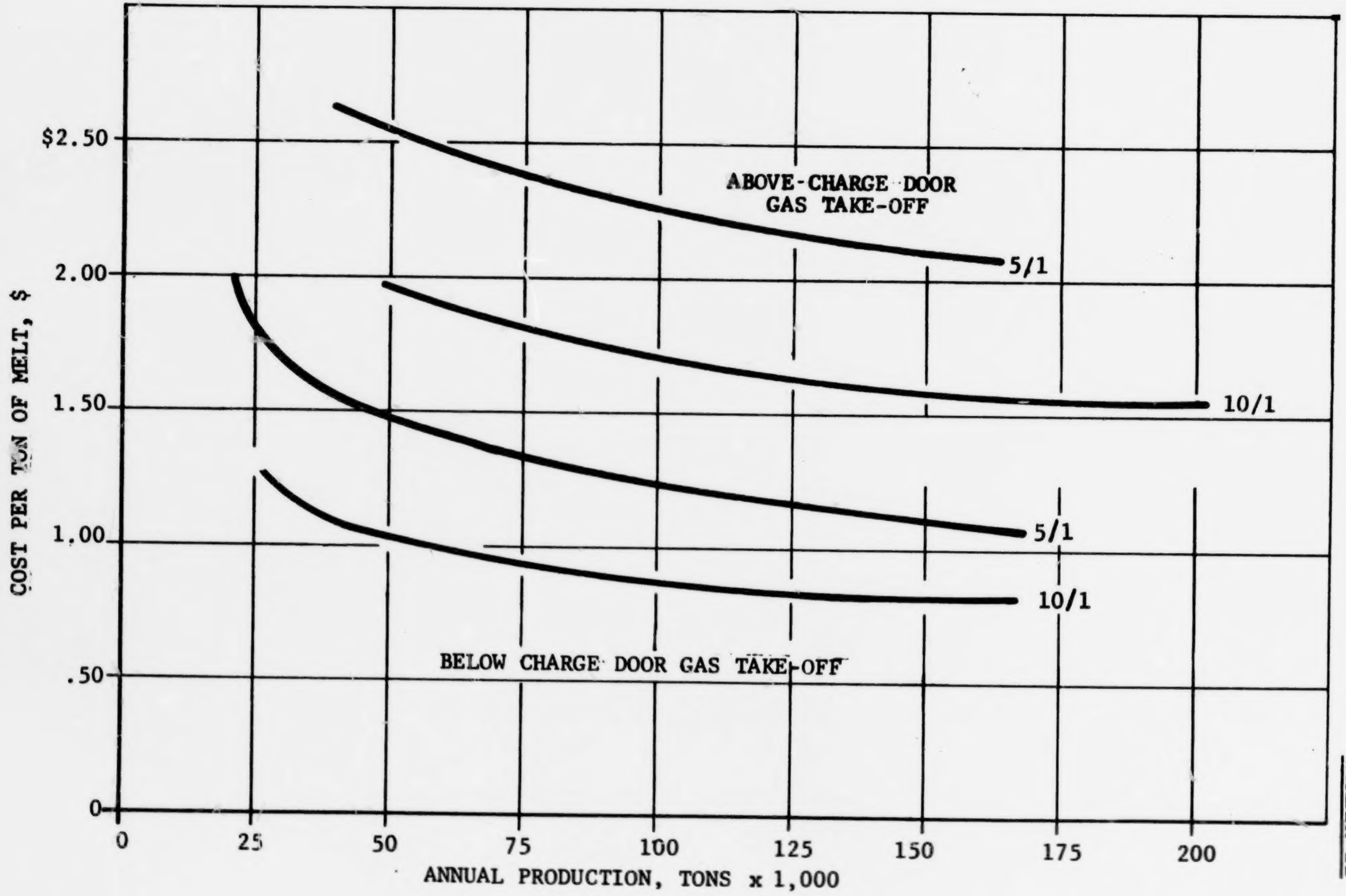


APPENDIX D
NUMBER 21

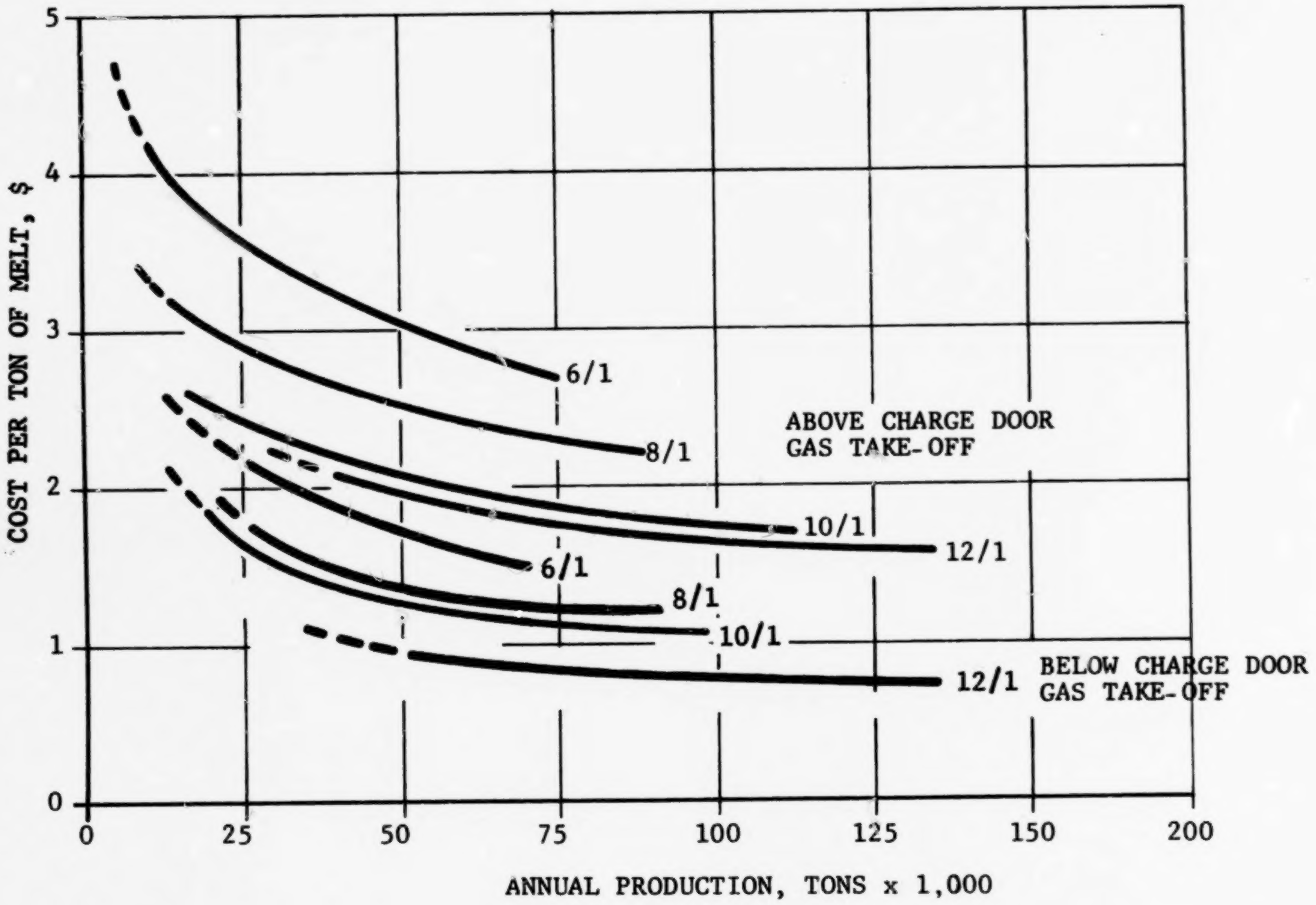


APPENDIX D
NUMBER 22

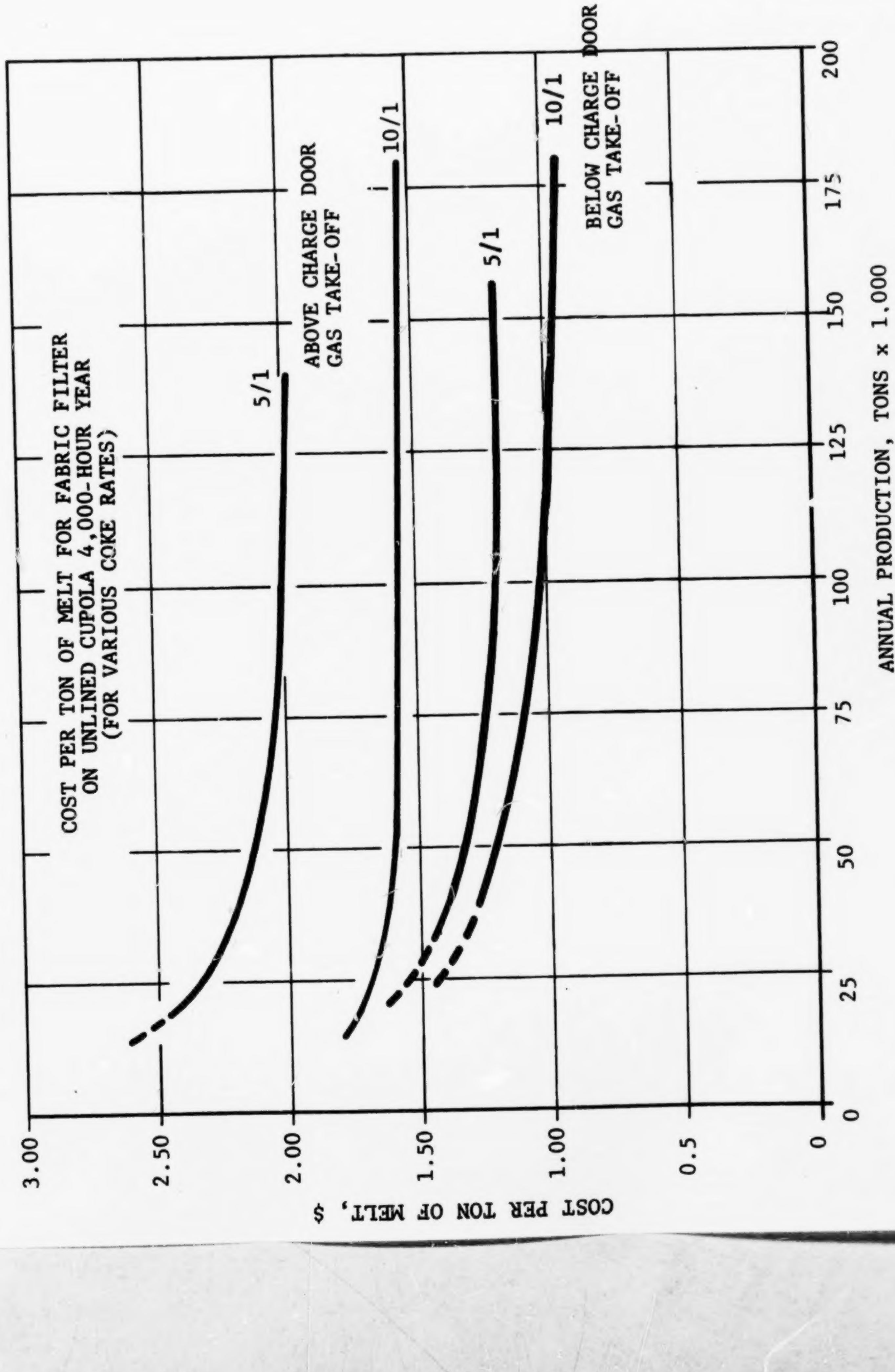
COST PER TON OF MELT FOR HIGH ENERGY
WET SCRUBBER ON UNLINED CUPOLA
4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



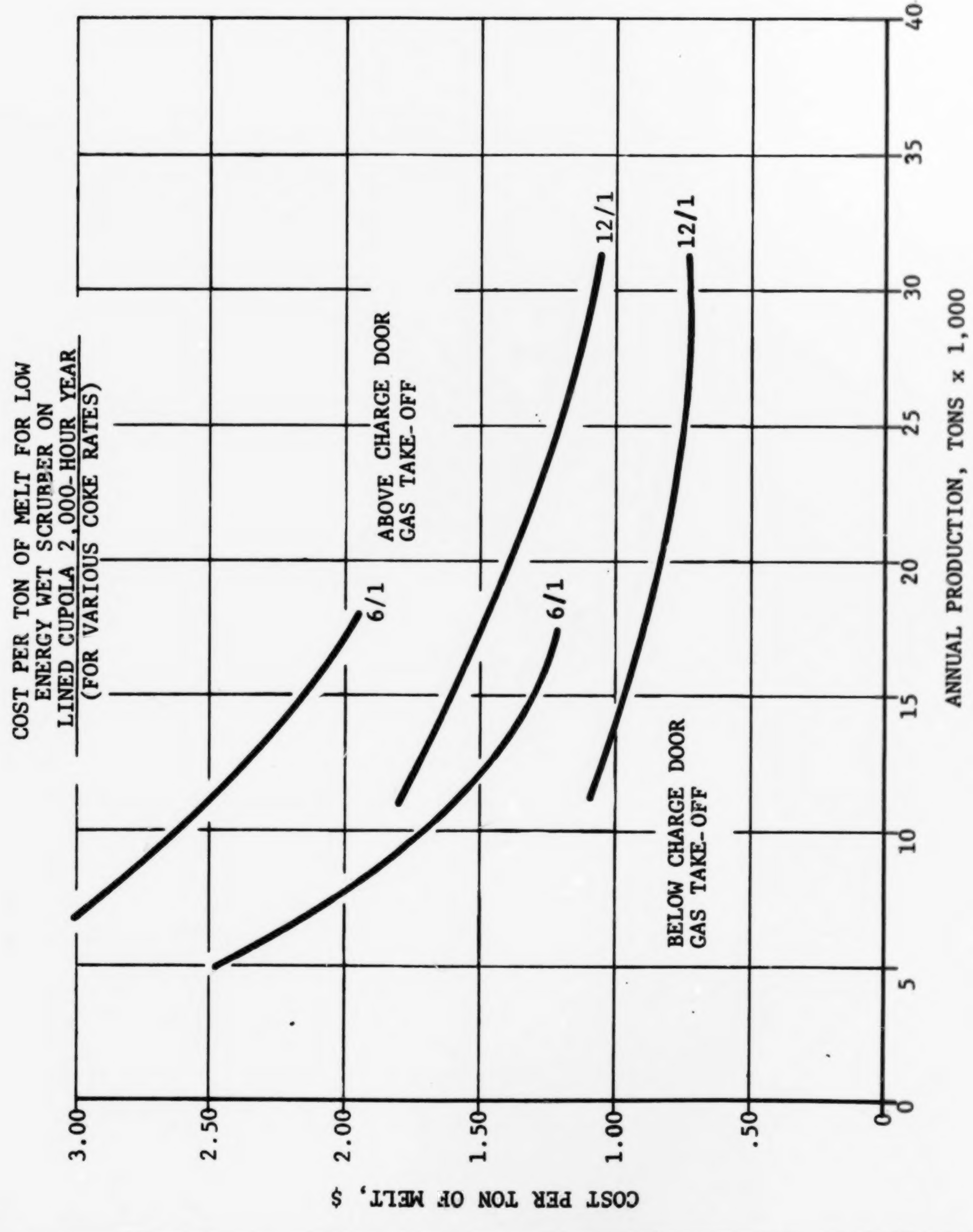
COST PER TON OF MELT FOR FABRIC FILTER
ON LINED CUPOLA 4,000-HOUR YEAR
(FOR VARIOUS COKE RATES)



APPENDIX D
NUMBER 24



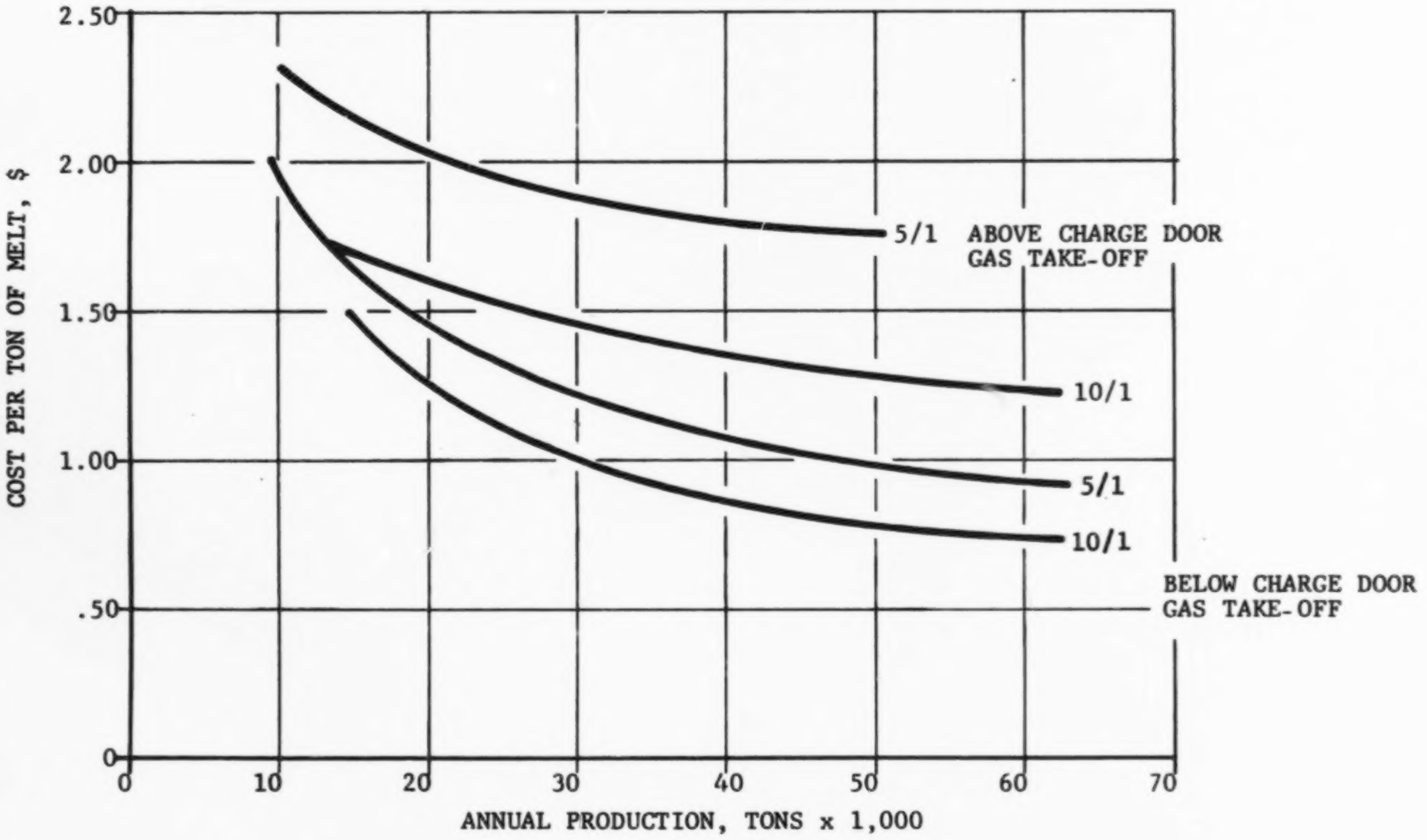
COST PER TON OF MELT FOR FABRIC FILTER ON UNLINED CUPOLA 4,000-HOUR YEAR (FOR VARIOUS COKE RATES)

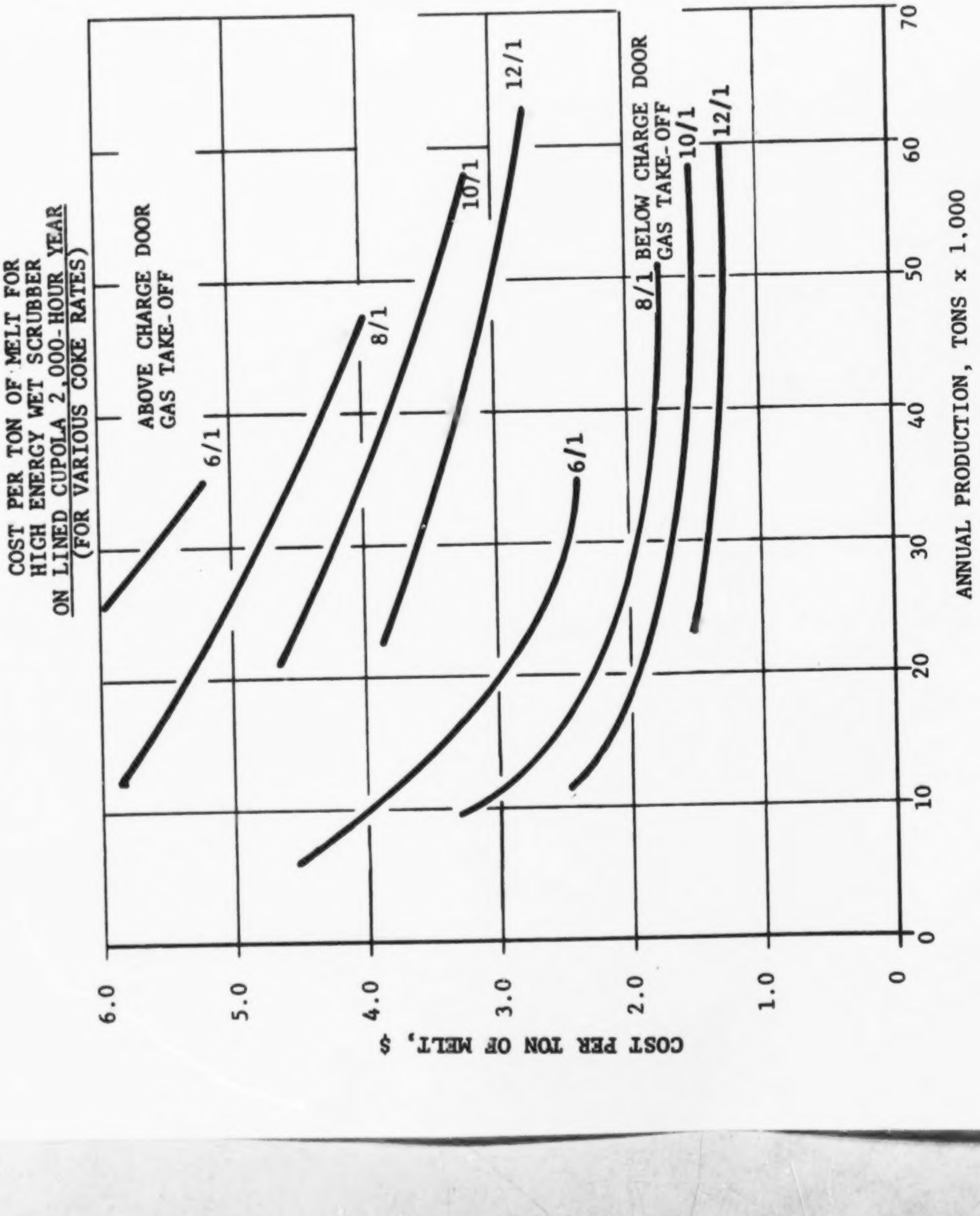


COST PER TON OF MELT FOR LOW ENERGY WET SCRUBBER ON LINED CUPOLA 2,000-HOUR YEAR (FOR VARIOUS COKE RATES)

APPENDIX D
NUMBER 26

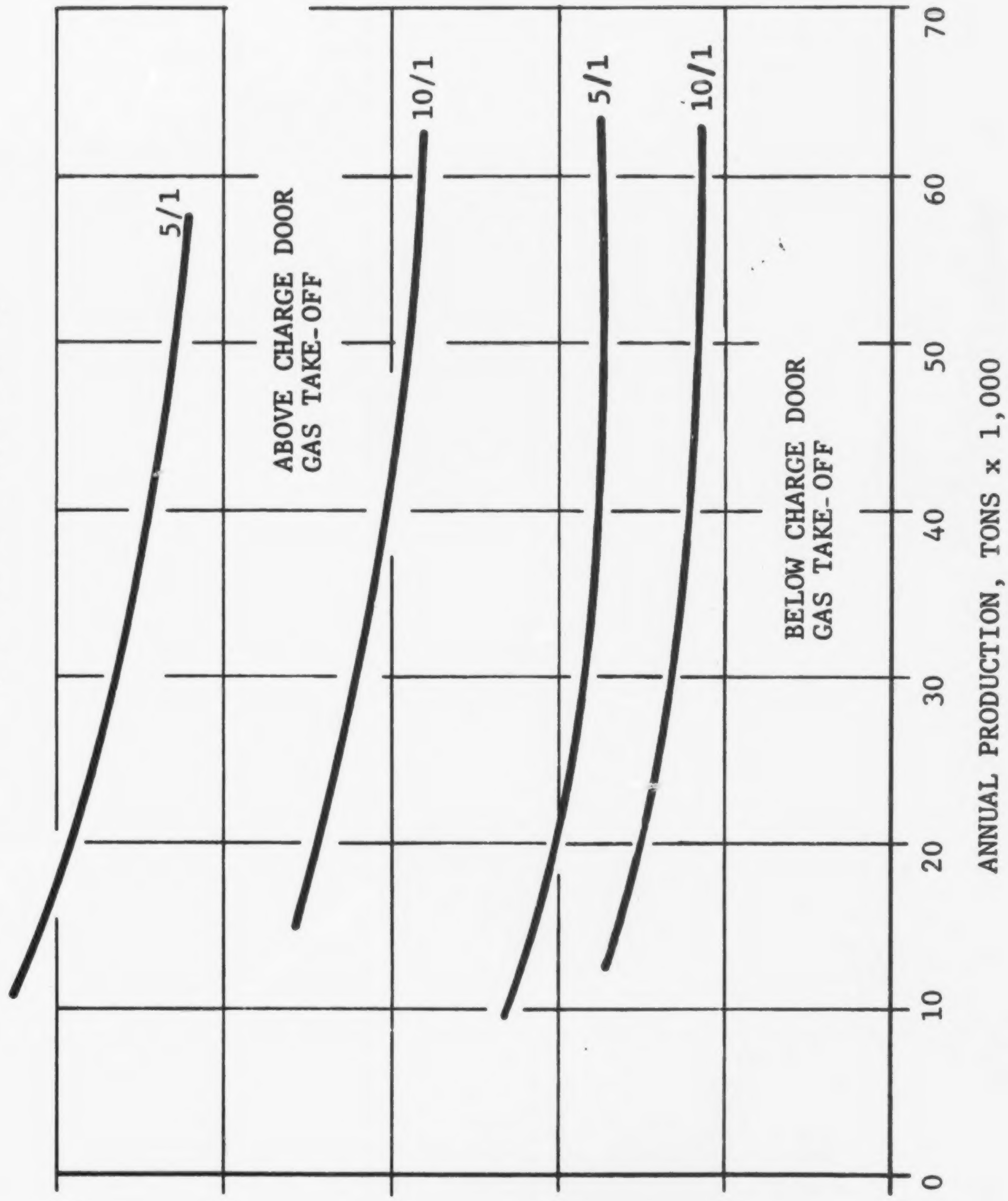
COST PER TON OF MELT FOR
LOW ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

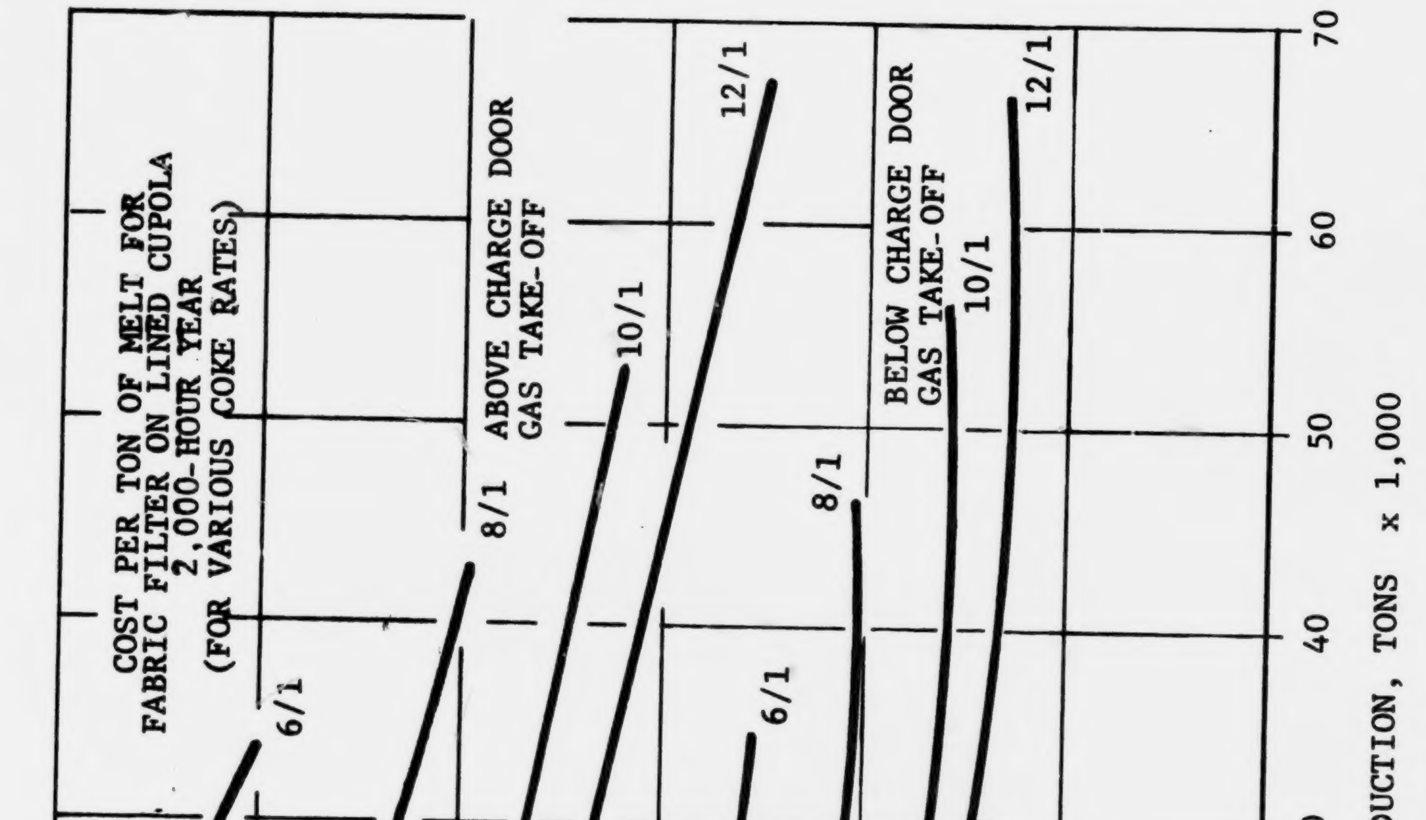




COST PER TON OF MELT FOR HIGH ENERGY WET SCRUBBER ON LINED CUPOLA 2,000-HOUR YEAR (FOR VARIOUS COKE RATES)

COST PER TON OF MELT FOR
HIGH ENERGY WET SCRUBBER
ON UNLINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

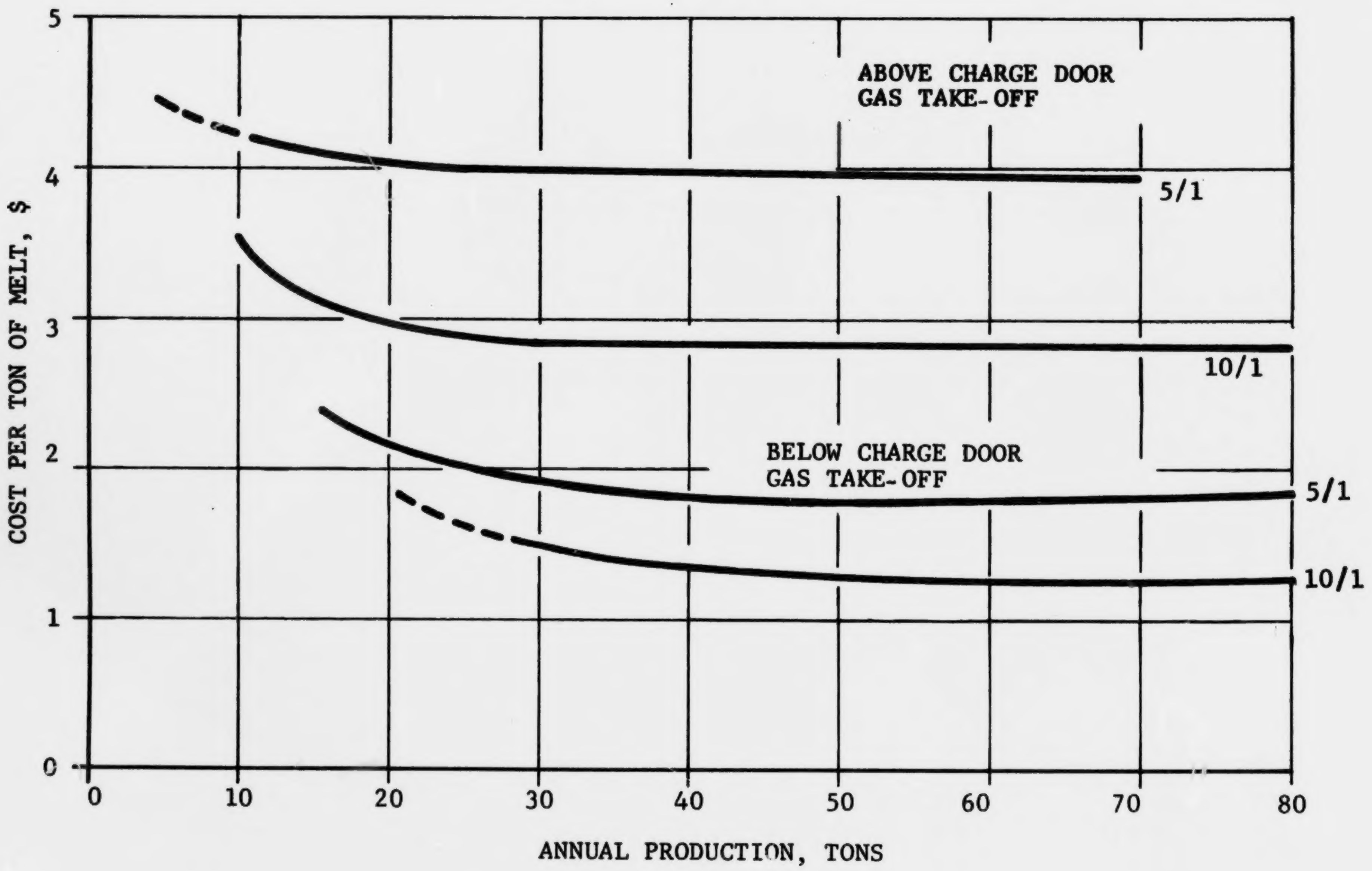




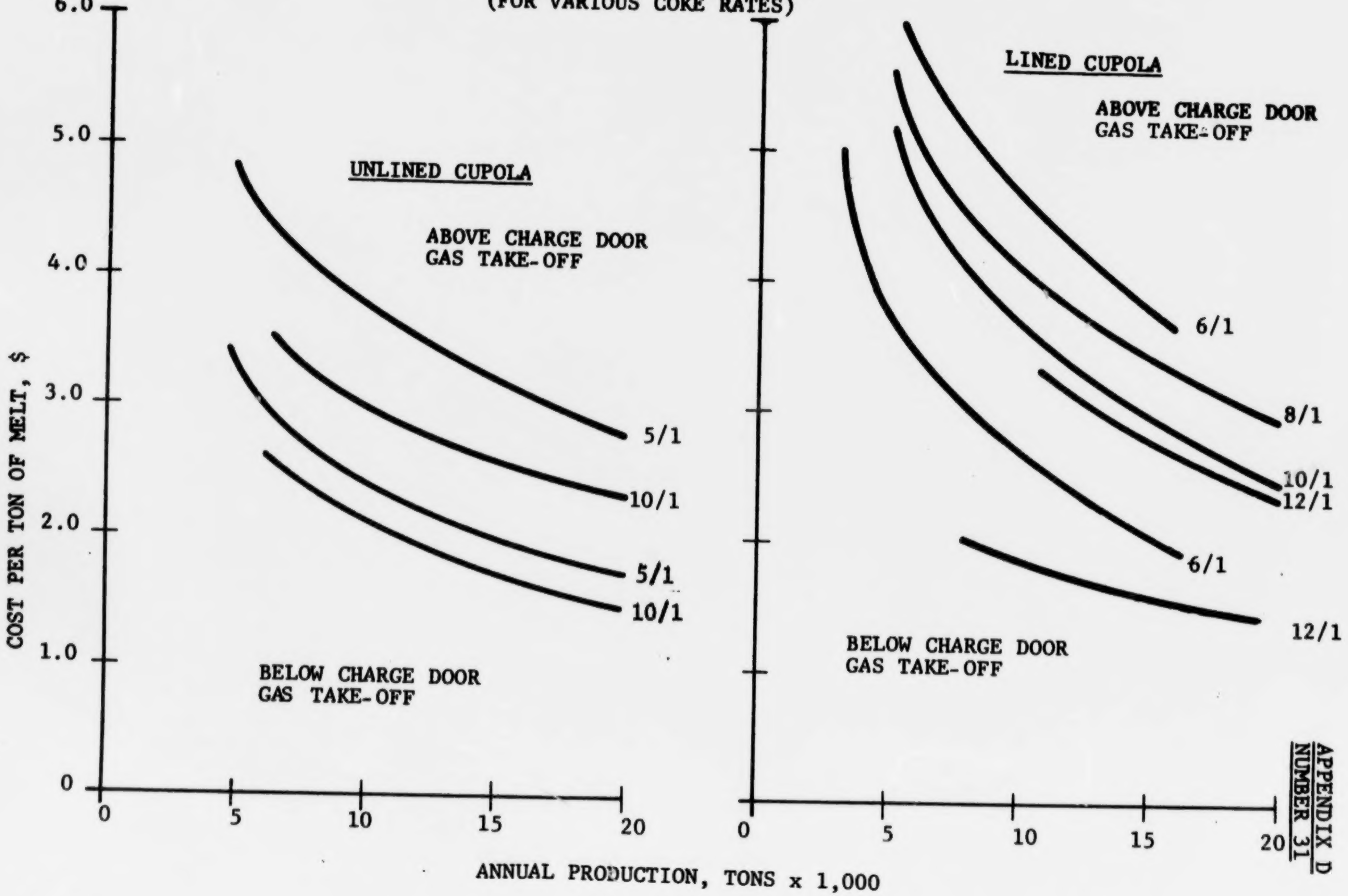
COST PER TON OF MELT FOR FABRIC FILTER ON LINED CUPOLA
2,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

APPENDIX D
NUMBER 30

COST PER TON OF MELT FOR FABRIC FILTER ON UNLINED CUPOLA 2,000-HOUR-YEAR (FOR VARIOUS COKE RATES)

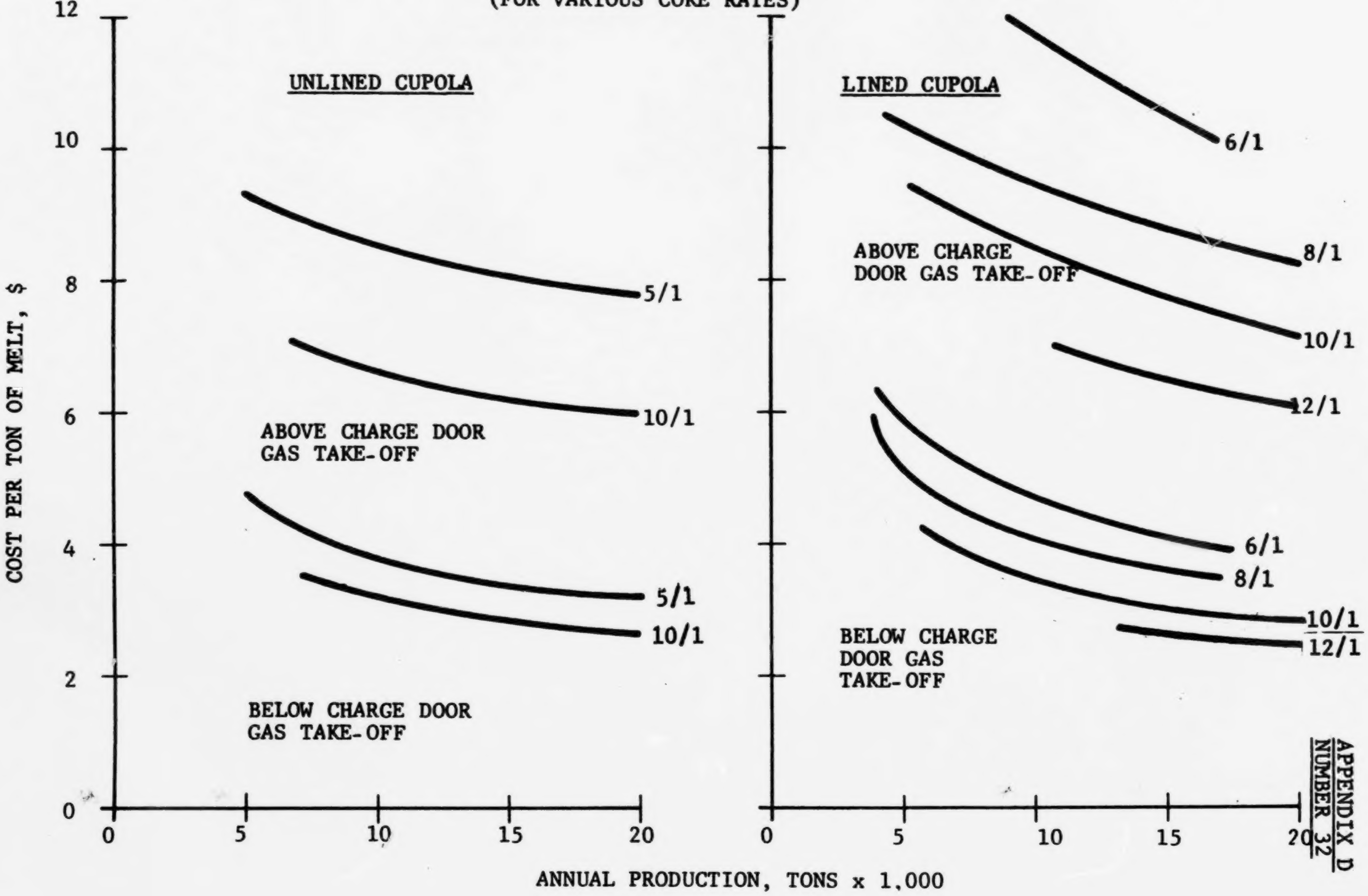


COST PER TON OF MELT FOR
LOW ENERGY WET SCRUBBER
ON CUPOLA 1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

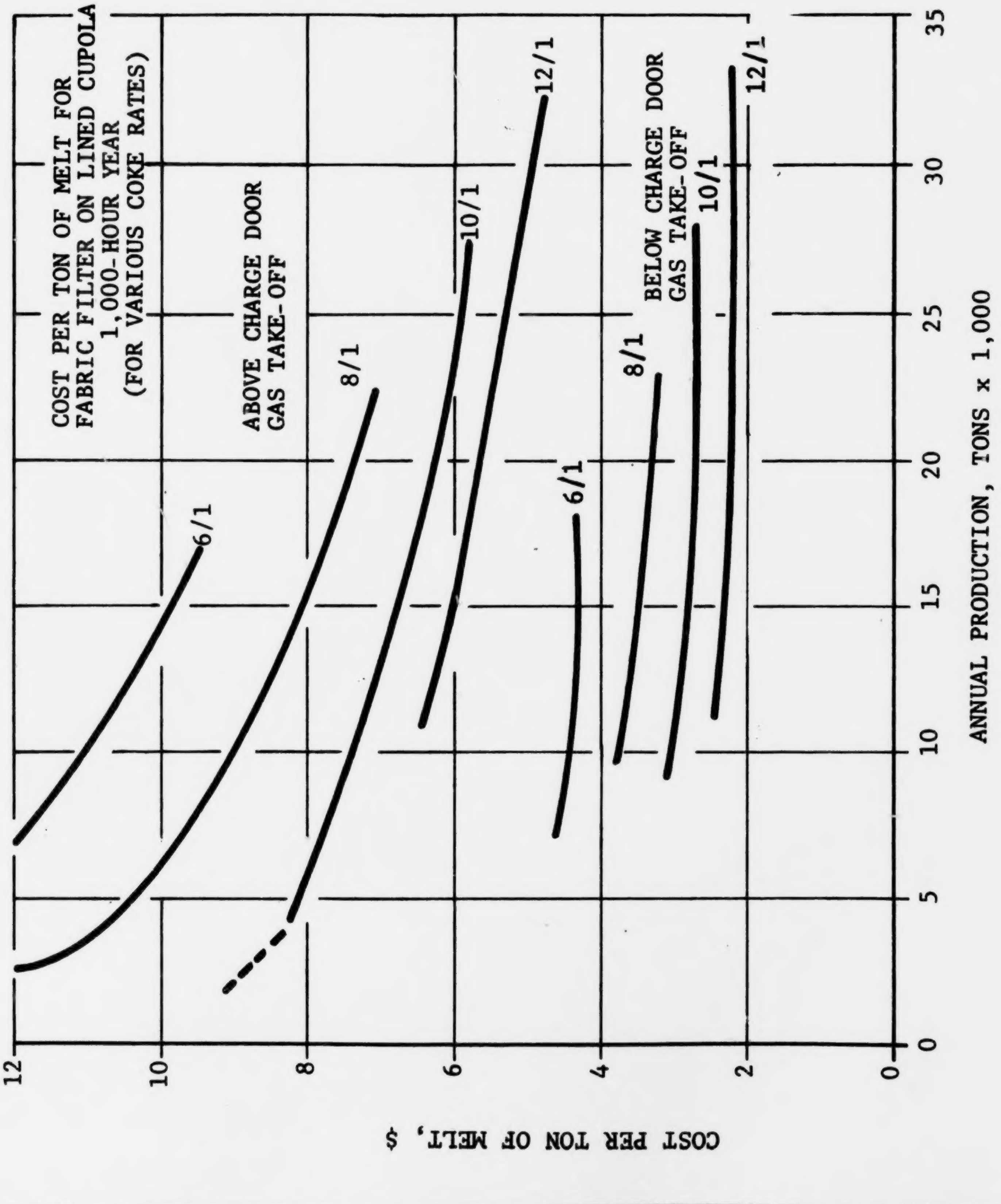


APPENDIX D
NUMBER 32

COST PER TON OF MELT FOR HIGH ENERGY WET SCRUBBER ON CUPOLA 1,000-HOUR YEAR (FOR VARIOUS COKE RATES)

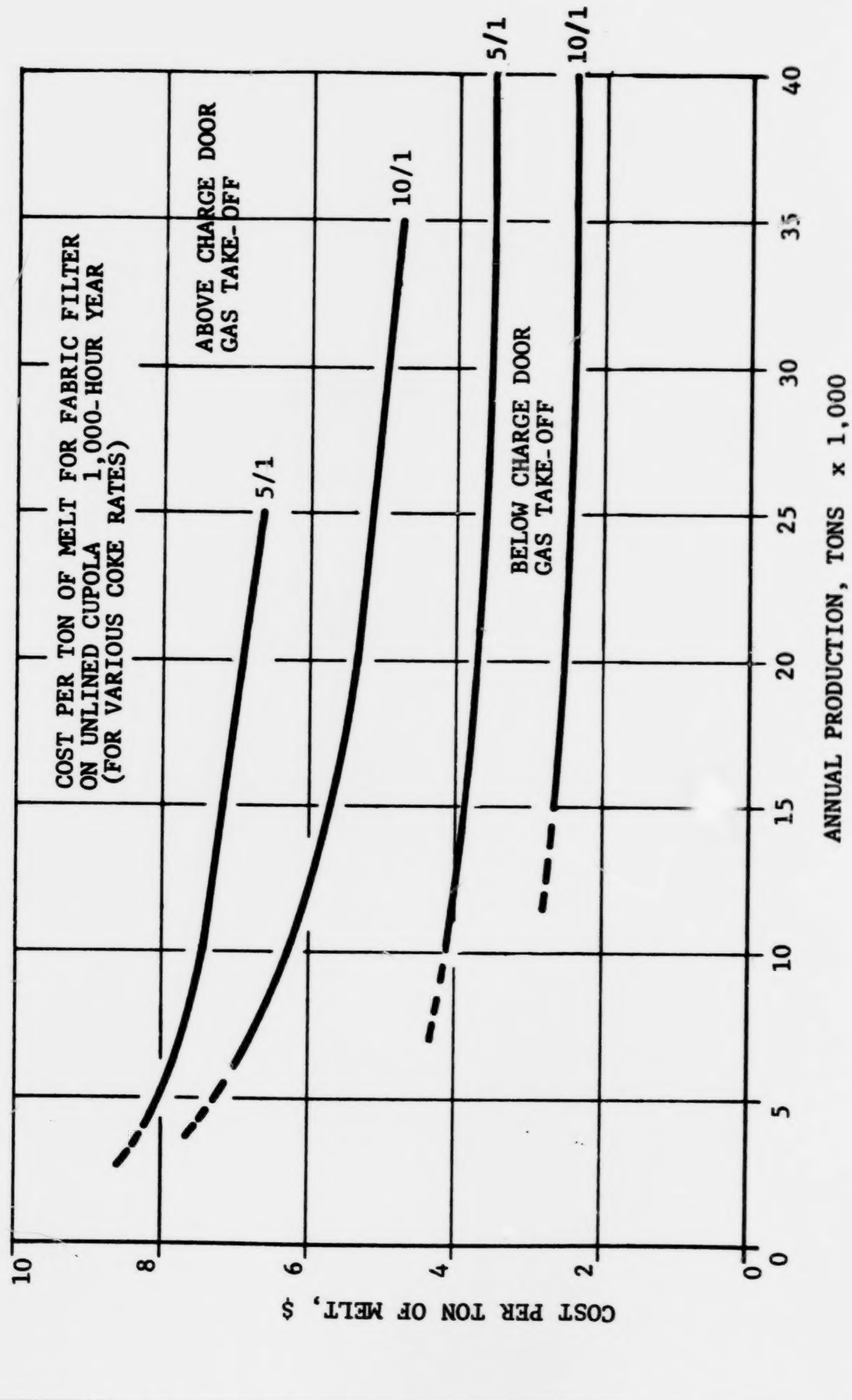


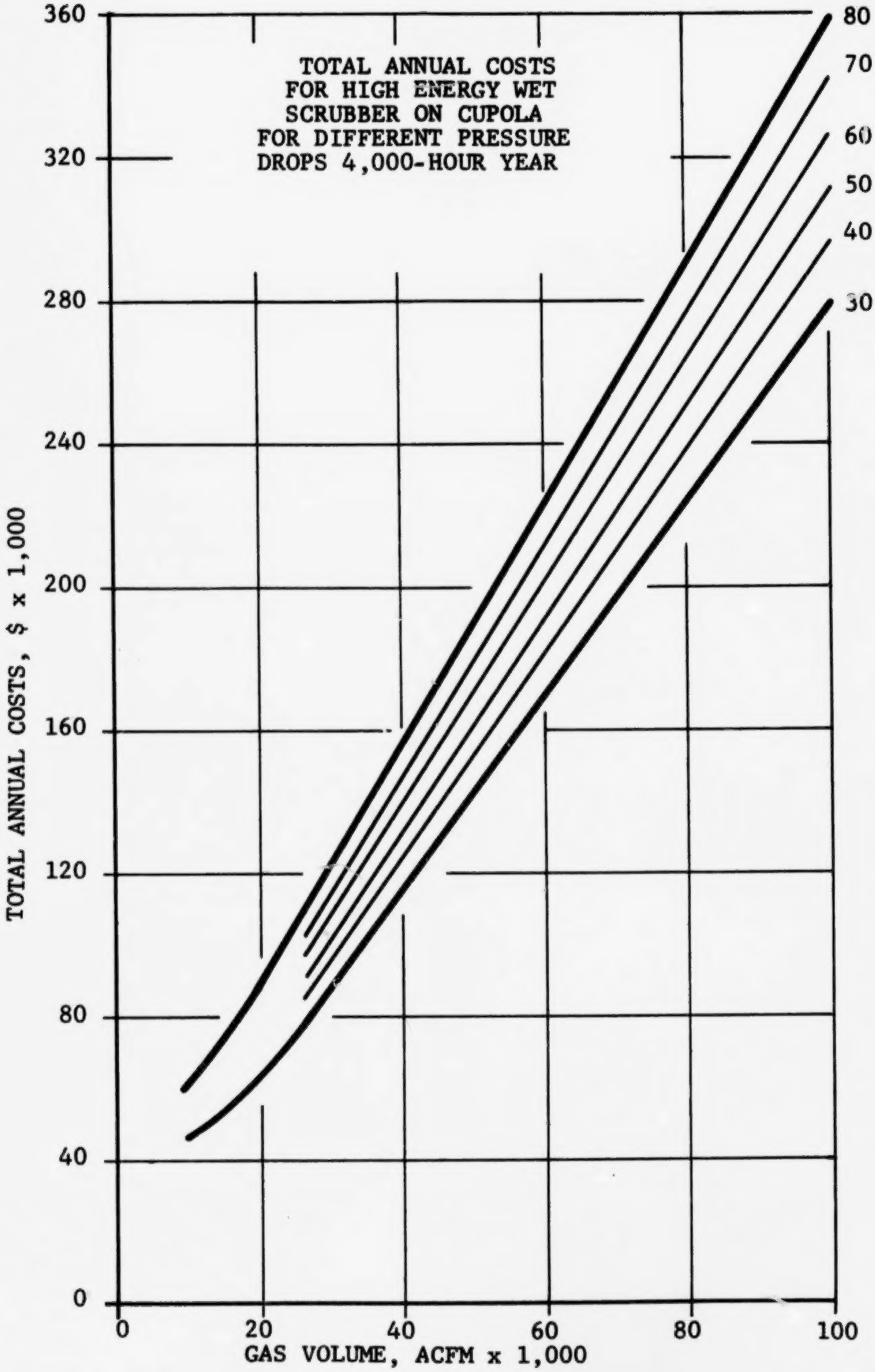
APPENDIX D
NUMBER 33



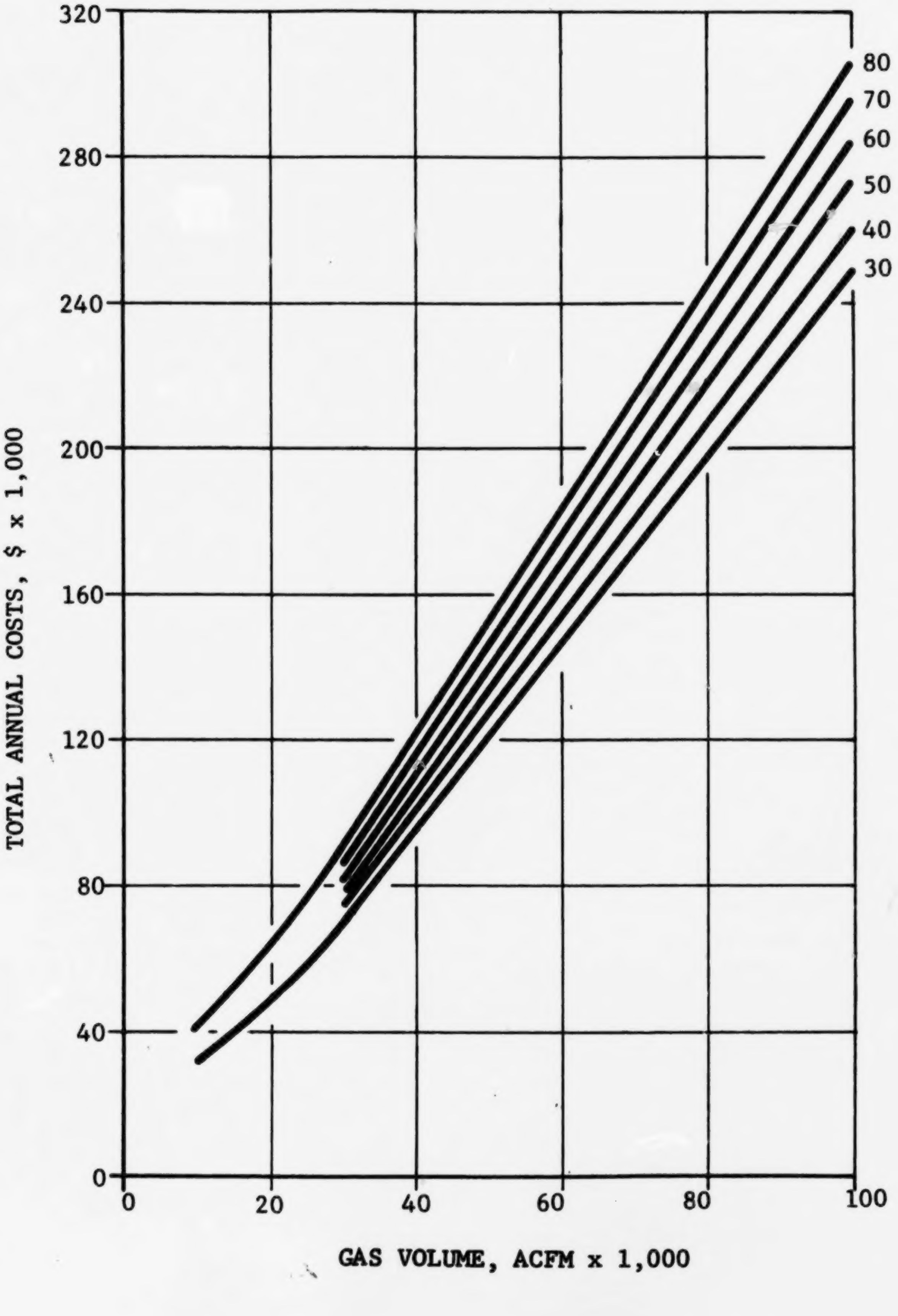
COST PER TON OF MELT FOR FABRIC FILTER ON LINED CUPOLA
1,000-HOUR YEAR
(FOR VARIOUS COKE RATES)

APPENDIX D
NUMBER 34

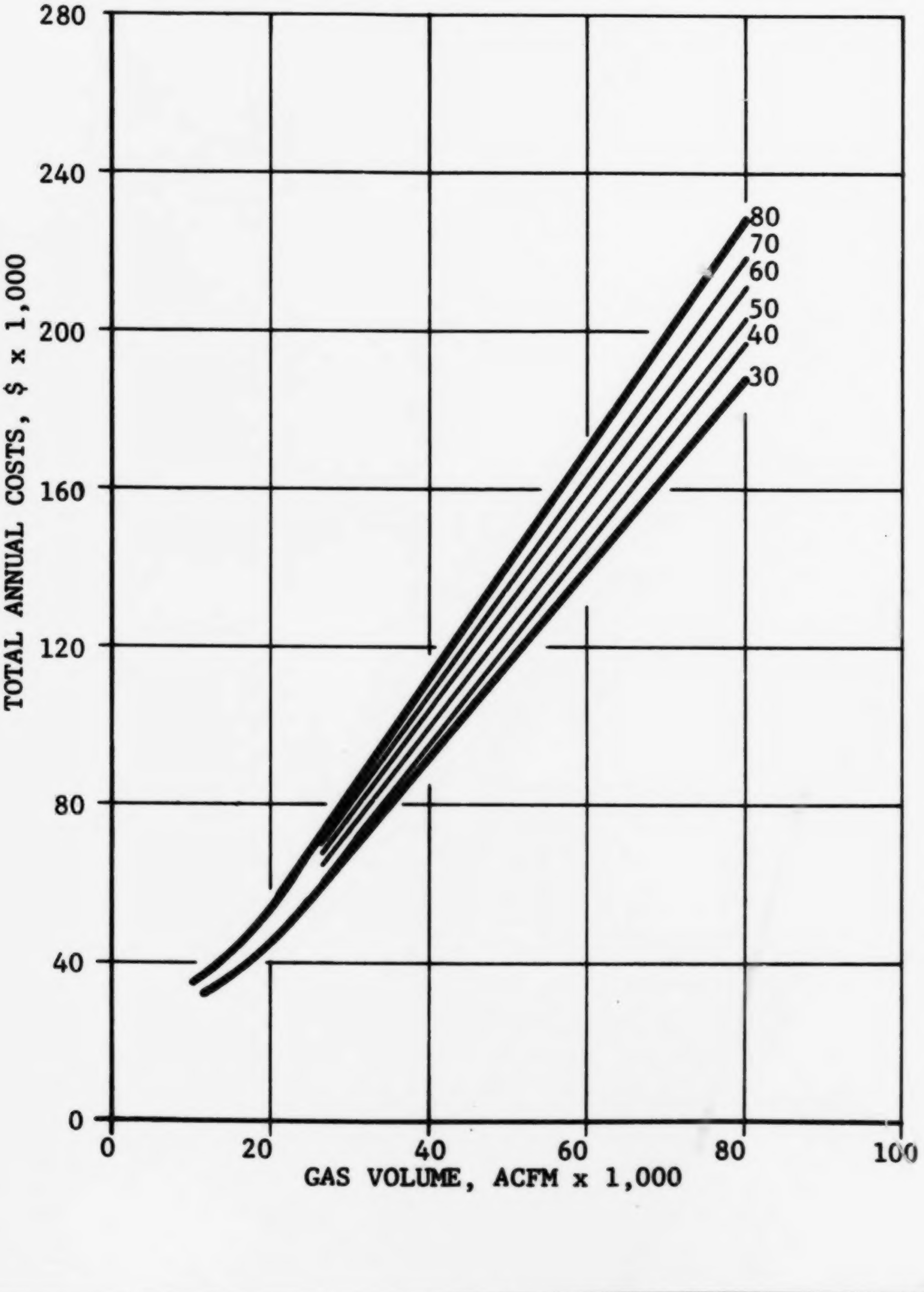



TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON CUPOLA FOR DIFFERENT PRESSURE DROPS 4,000-HOUR YEAR
TOTAL ANNUAL COSTS, $ x 1,000
GAS VOLUME, ACFM x 1,000
0
40
80
120
160
200
240
280
320
360
0
20
40
60
80
100
80
70
60
50
40
30

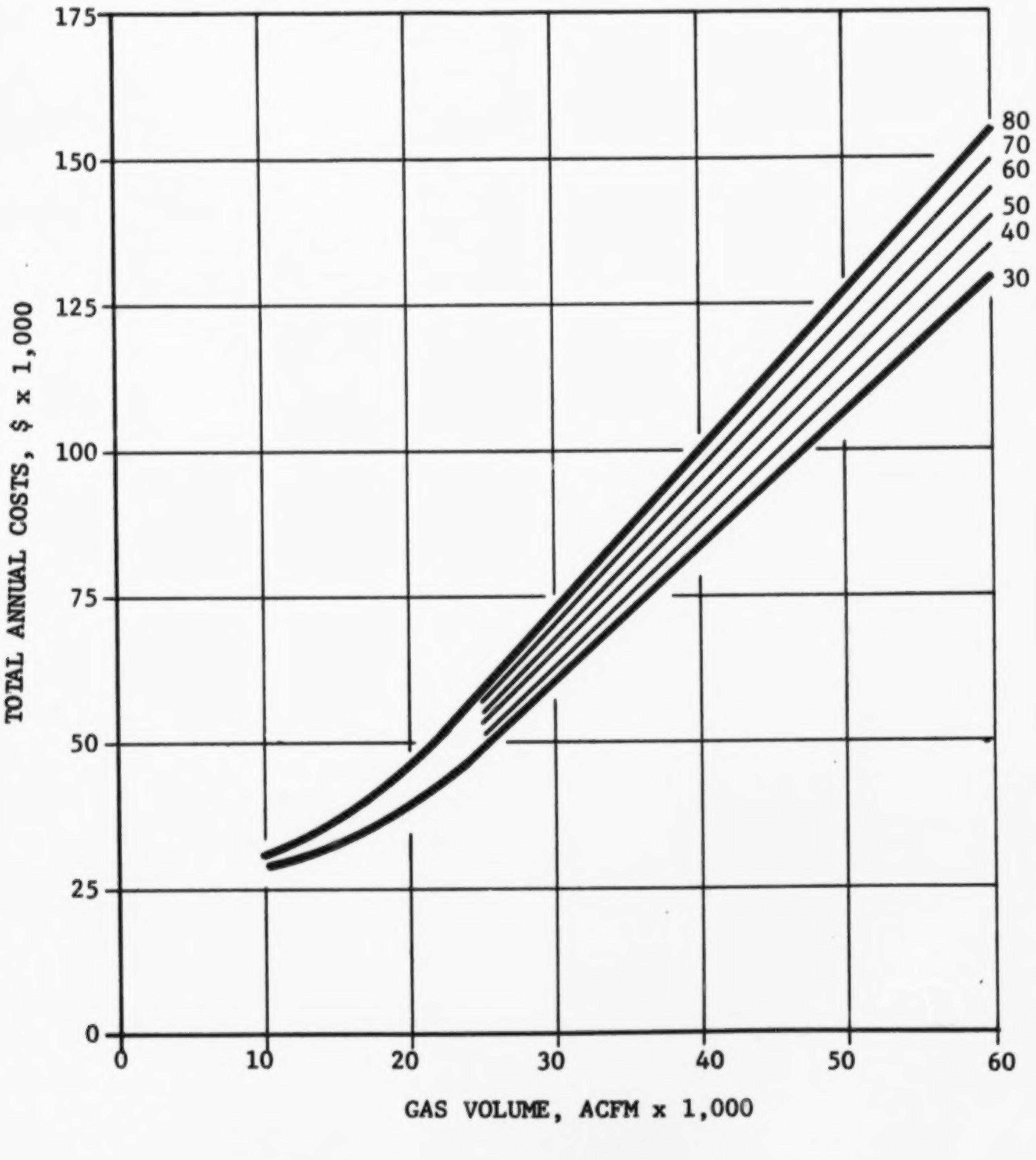
TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON CUPOLA FOR DIFFERENT PRESSURE DROPS 2,000-HOUR YEAR



TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON CUPOLA FOR DIFFERENT PRESSURE DROPS 1,000-HOUR YEAR



TOTAL ANNUAL COSTS FOR HIGH ENERGY WET SCRUBBER ON CUPOLA FOR DIFFERENT PRESSURE DROPS 500-HOUR YEAR



EQUIPMENT REQUIREMENTS

CUPOLA, COLD BLAST, NO HOLDING
FURNACE, FABRIC FILTER EMISSION CONTROL
FOR 500 & 1,000 HOURS PER YEAR

	5 TPH		15
	Number and Size	Cost	Number and Size
A. **Buildings**			
1. Cupola Building 500 & 1,000 Hours per Year, $25/Sq. Ft.	2,500 Sq. Ft.	$ 63,000	4,000 Sq. Ft.
2. Cupola Auxiliary Building $10/Sq. Ft.	750 Sq. Ft.	8,000	1,800 Sq. Ft.
B. **Scrapyard Equipment**			
1. Scrapyard Crane	1-5T	60,000	1-7½T
2. Crane Runway	12,500 Open	19,000	16,000 Covere
3. Metal Trim Platform & Weigh Hopper		20,000	
4. Coke & Stone Weigh Hoppers & Feeders		-	
5. Coke & Stone Bins		15,000	
6. Coke & Stone Unloading Equipment		10,000	
7. Magnet	1-45"	6,000	1-65"
8. Platform Scale		10,000	
C. **Charging Equipment**			
1. Skip Charger	-	-	1-15 TPH
2. Charge Buckets		24,000	
D. **Melting Equipment**			
1. Cupolas @ 500 & 1,000 H/A	1-56"	14,000	1-90"
2. Blower & Motor (SCFM Basis)	1-3,100	26,000	1-9,200
3. Air Piping, Piping, Valves & Weight Control		25,000	
4. Forehearth		5,000	
5. Runners		3,000	
6. Refractories for Cupola & Runners		10,000	
7. Slag Buckets		5,000	
8. Slag Disposal Equipment		-	
9. Piping, Header, & Sewer Connections		10,000	
E. **Holding Equipment** (Not Required)			
Subtotal #1 (B + C + D + E)		$262,000	
F. **Spares & Freight** (3½% of B, C, D, E)		$ 9,000	
Subtotal #2 (S.T. #1 + A + F)		$342,000	
G. **Engineering** 5%		$ 17,000	
Subtotal		$359,000	
H. **Contingencies** 10%		$ 36,000	
Total		$395,000	
Cost/Ton			
500 Hours		$158	
1,000 Hours		79	

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APPENDIX D
NUMBER 39
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EQUIPMENT REQUIREMENTS

CUPOLA, COLD BLAST, NO HOLDING
RNACE, FABRIC FILTER EMISSION CONIROL
FOR 500 & 1,000 HOURS PER YEAR

5 TPH		15 TPH		30 TPH		50 TPH	
Number and Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
500 Sq. Ft.	$ 63,000	4,000 Sq. Ft.	$100,000	8,000 Sq. Ft.	$200,000	10,000 Sq. Ft.	$250,000
750 Sq. Ft.	8,000	1,800 Sq. Ft.	18,000	3,000 Sq. Ft.	30,000	5,000 Sq. Ft.	50,000
5T	60,000	1-7½T	83,000	2-7½T	166,000	2-10T	200,000
,500 Open	19,000	16,000 Covered	128,000	24,000 Covered	192,000	30,000 Covered	240,000
	20,000		55,000		70,000		90,000
	-		95,000		143,000		240,000
	15,000		-		-		-
	10,000		40,000		52,000		75,000
5"	6,000	1-65"	8,000	2-65"	16,000	3-65"	24,000
	10,000		-		-		-
	-	1-15 TPH	134,000	2-15 TPH	238,000	2-30 TPH	330,000
-	24,000		-		-		-
6"	14,000	1-90"	34,000	2-90"	67,000	2-108"	80,000
,100	26,000	1-9,200	36,000	2-9,200	72,000	2-12,500	175,000
	25,000		40,000		50,000		72.000
	5,000		6,000		12,000		15,000
	3,000		4,000		6,000		8,000
	10,000		29,000		58,000		70,000
	5,000		-		-		-
	-		21,000		27,000		36,000
	10,000		20,000		25,000		30,000
	$262,000		$733,000		$1,194,000		$1,685,000
	$ 9,000		$ 25,000		$ 42,000		$ 59,000
	$342,000		$876,000		$1,466,000		$2,044,000
	$ 17,000		$ 44,000		$ 73,000		$ 102,000
	$359,000		$920,000		$1,539,000		$2,146,000
	$ 36,000		$ 92,000		$ 154,000		$ 215,000
	$395,000		$1,012,000		$1,693,000		$2,361,000
	$158 79		$67.47				

B

EQUIPMENT REQUIREMENTS

CUPOLA, COLD BLAST, NO HOLDING
FURNACE, SUPPLEMENTARY COSTS
FOR 2,000 & 4,000 HOURS PER YEAR

	Increase For 2,000 & 4,000/ Hours per Year	5 TPH		
		Number and Size	Cost	Numbe and Si
A. **Buildings**				
Cupola Building	80%		$ 50,000	
C. **Charging Equipment**				
Swivel Skip Charger	15%		3,000	
D. **Melting Equipment**				
1. Cupolas	100%		14,000	
3. Air Piping & Valves	10		3,000	
6. Runners	50		2,000	
7. Refractories	100		10,000	
9. Slag Disposal Equipment	15		1,000	
5. Forehearth	100		5,000	
Subtotal #1 (C + D)			$ 38,000	
E. Spares & Freight 3-1/2%			$ 1,000	
Subtotal (#1 + A + E)			$ 89,000	
Engineering 5%			$ 4,000	
Subtotal			$ 93,000	
Contingencies 10%			$ 9,000	
Subtotal			$102,000	
Total from 500 & 1,000 Hours Page 1.			$395,000	
Grand Total			$497,000	
Cost/Ton				
2,000 Hours			$49.70	
4,000 Hours				

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APPENDIX D
NUMBER 39
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EQUIPMENT REQUIREMENTS

UPOLA, COLD BLAST, NO HOLDING
FURNACE, SUPPLEMENTARY COSTS
R 2,000 & 4,000 HOURS PER YEAR

5 TPH		15 TPH		30 TPH		50 TPH	
mber d Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
	$ 50,000		$ 80,000		$ 160,000		$ 200,000
	3,000		20,000		36,000		50,000
	14,000		34,000		67,000		80,000
	3,000		4,000		5,000		7,000
	2,000		2,000		3,000		4,000
	10,000		29,000		58,000		70,000
	1,000		3,000		4,000		5,000
	5,000		6,000		12,000		15,000
	$ 38,000		$ 98,000		$ 185,000		$ 231,000
	$ 1,000		$ 3,000		$ 6,000		$ 9,000
	$ 89,000		$ 181,000		$ 351,000		$ 440,000
	$ 4,000		$ 9,000		$ 18,000		$ 22,000
	$ 93,000		$ 190,000		$ 369,000		$ 462,000
	$ 9,000		$ 19,000		$ 37,000		$ 46,000
	$102,000		$ 209,000		$ 406,000		$ 508,000
	$395,000		$1,012,000		$1,693,000		$2,361,000
	$497,000		$1,221,000		$2,099,000		$2,869,000
	$49.70		$40.70 20.35		$34.98 17.49		$28.69 14.35

B

EQUIPMENT REQUIREMENTS

CUPOLA, HOT BLAST, WATER-COOLE
CHANNEL INDUCTION HOLDING FURNA
WET SCRUBBER EMISSION CONTRO

	5 TPH		
	Number and Size	Cost	N an
A. **Buildings**			
1. Melting Building @ $25/Sq. Ft.	2,000	$ 50,000	1-2,50
2. Cupola Auxiliary Building @ $10/Sq. Ft.	1,000	10,000	1,500
B. **Scrapyard Equipment**			
1. Scrapyard Crane	1-5T	60,000	1-7½ T
1A. Crane Runway & Stockyard	12,500 Open	19,000	16,000
2. Metal Trim Platform & Weigh Hopper	Lump Sum	20,000	Lump S
4. Coke & Stone Weigh Hoppers, Feeders, Scales & Bins		-	Lump S
5. Coke & Stone Unloading Equipment	Lump Sum	10,000	Lump S
6. Magnets	1-45"	6,000	1-65"
7. Platform Scale	Lump Sum	10,000	
C. **Charging Equipment**			
1. Skip Charger-Swivel Type		-	1-15 TP
2. Charge Buckets		24,000	
D. **Melting Equipment**			
1. Cupola-Unlined-Water Cooled	1-36"	40,000	1-66"
2. Air Piping, Gates, Charge Indicator	Lump Sum	50,000	Lump Su
3. Blower & Motor	2,300 SCFM	25,000	7,700 S
4. Forehearth-Lined	1	5,000	1
5. Runners	Lump Sum	3,000	Lump Su
6. Refractories for Runners	Lump Sum	1,500	Lump Su
7. Gas Piping & Meter	Lump Sum	7,500	Lump Su
8. Hot Blast Heater	Lump Sum	65,000	Lump Su
9. Piping, Headers, Sewer Connections	Lump Sum	15,000	Lump Su
10. Slag Disposal Equipment	Lump Sum	5,000	Lump Su
11. Water Cooling Tower & Pumps	Lump Sum	20,000	Lump Su
E. **Holding Equipment**			
1. Channel Induction Furnace & Controls		-	1-13½T 5
1A. Spare Furnace Body		-	Lump Sum
3. Refractories for Holding Furnaces		-	Lump Sum
Subtotal #1 (B + C + D + E)		$366,000	
F. Spares & Freight (3½% of B + C + D + E)		$ 13,000	
Subtotal #2 (St. #1 + A + F)		$439,000	
G. Engineering (5% of St. #2)		$ 22,000	
Subtotal #3 (G + St. #2)		$461,000	
H. Contingencies (10% of St. #3)		$ 46,000	
Total (St. #3 + H)		$507,000	
Cost/Ton			
2,000 Hours		$50.70	
4,000 Hours			

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APPENDIX D
NUMBER 40

EQUIPMENT REQUIREMENTS

CUPOLA, HOT BLAST, WATER-COOLED, CHANNEL INDUCTION HOLDING FURNACE, WET SCRUBBER EMISSION CONTROL

5 TPH		15 TPH		30 TPH		50 TPH	
Number and Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
,000	$ 50,000	1-2,500 Sq. Ft.	$ 63,000	1-4,000 Sq. Ft.	$100,000	1-5,000 Sq. Ft.	$125,000
,000	10,000	1,500 Sq. Ft.	15,000	1-3,000 Sq. Ft.	30,000	5,000 Sq. Ft.	50,000
-5T	60,000	1-7½ T-70'	83,000	2-7½ T	166,000	2-10T	200,000
2,500 Open	19,000	16,000 Sq. Ft.	128,000	25,000 Sq. Ft.	192,000	30,000 Sq. Ft.	240,000
ump Sum	20,000	Lump Sum	55,000	Lump Sum	70,000	Lump Sum	90,000
	-	Lump Sum	95,000	Lump Sum	143,000	Lump Sum	240,000
ump Sum	10,000	Lump Sum	40,000	Sum	52,000	Lump Sum	75,000
-45"	6,000	1-65"	8,000	2 -65"	16,000	3-65"	24,000
mp Sum	10,000		-		-		-
	-	1-15 TPH	134,000	1-30 TPH	165,000	1-50 TPH	225,000
	24,000		-		-		-
36"	40,000	1-66"	80,000	1-90"	180,000	1-108"	265,000
mp Sum	50,000	Lump Sum	66,000	Lump Sum	84,000	Lump Sum	150,000
300 SCFM	25,000	7,700 SCFM	30,000	14,300 SCFM	52,000	20,600 SCFM	120,000
	5,000	1	6,000	1	12,000	1	15,000
mp Sum	3,000	Lump Sum	3,000	Lump Sum	4,500	Lump Sum	5,000
mp Sum	1,500	Lump Sum	2,000	Lump Sum	3,000	Lump Sum	5,000
mp Sum	7,500	Lump Sum	10,000	Lump Sum	12,000	Lump Sum	15,000
mp Sum	65,000	Lump Sum	75,000	Lump Sum	112,000	Lump Sum	195,000
p Sum	15,000	Lump Sum	20,000	Lump Sum	25,000	Lump Sum	30,000
p Sum	5,000	Lump Sum	21,000	Lump Sum	27,000	Lump Sum	36,000
mp Sum	20,000	Lump Sum	30,000	Lump Sum	40,000	Lump Sum	50,000
	-	1-13½T 500KW	100,000	1-20/8 800KW	200,000	1-60T 1,200KW	350,000
	-	Lump Sum	30,000	Lump Sum	80,000	Lump Sum	125,000
	-	Lump Sum	20,000	Lump Sum	45,000	Lump Sum	90,000
	$366,000		$1,036,000		$1,680,500		$2,545,000
	$ 13,000		$ 36,000		$ 59,000		$ 89,000
	$439,000		$1,150,000		$1,869,500		$2,809,000
	$ 22,000		$ 58,000		$ 93,000		$ 140,000
	$461,000		$1,208,000		$1,962,500		$2,949,000
	$ 46,000		$ 121,000		$ 196,000		$ 295,000
	$507,000		$1,329,000		$2,158,500		$3,244,000
	$50.70		$44.30 22.15		$35.98 17.99		$32.44 16.22

B

EQUIPMENT REQUIREMENTS

ELECTRIC ARC FURNACE, CHANNEL INDUCTION HOLDING, FABRIC FILTER EMISSION CONTROL

	5 TPH		15 TPH	
	Number and Size	Cost	Number and Size	
A. Buildings				
Melting Building $13/Sq. Ft.	10,000 Sq. Ft.	$ 130,000	18,000	$
Transformer Rooms $10/Sq. Ft.	1,200 Sq. Ft.	12,000	1,500 Sq. Ft.	
B. Scrapyard Equipment				
1. Scrapyard Crane	1-5T	60,000	1-7½T-80'	
2. Crane Runway & Stockyard	1-3T	19,000		
3. Platform Scales		15,000	1	
4. Magnets	1-45"	6,000	1-65"	
C. Charging Equipment				
1. Charge Bucket Transfer Cars & Track		10,000	Lump Sum	
2. Charge Buckets	2	10,000	3	
3. Charging Crane			1-25/45	
D. Melting Equipment				
1. Arc Furnaces	2-3T	410,000	2-11"-15T	
2. Transformers	1-5,000KVA	Included in D-1	2-7,500 KVA	I i
3. Furnace Refractories	Lump	9,000	Lump	
4. Electrodes	Lump	2,000	Lump	
5. Power Feeders, Piping Headers, Sewer Connections		10,000	Lump	
6. Slag Buckets	1	3,000	2	
E. Holding Equipment				
1. Channel Induction Furnaces & Electrics	None	-	1-30T 600 KW.	
2. Spare Furnace Body		-	1	
3. Refractories for Holding Furnaces	-	-	Lump	
Subtotal		$554,000		$1,
F. Spares & Freight		$ 19,000		$
Subtotal		$715,000		$2,
G. Engineering 5%		$ 36,000		$
Subtotal		$751,000		$2,
H. Contingencies 10%		$ 75,000		$
Total		$826,000		$2,
Cost/Ton				
500 Hours		$330		
1,000 Hours		165		
2,000 Hours		82.50		
1,000 Hours				
2,000 Hours				
4,000 Hours				

A

EQUIPMENT REQUIREMENTS

ELECTRIC ARC FURNACE, CHANNEL INDUCTION HOLDING, FABRIC FILTER EMISSION CONTROL

5 TPH		15 TPH		30 TPH		50 TPH	
Number and Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
,000 Sq. Ft.	$ 130,000	18,000	$ 234,000	25,000 Sq. Ft.	$ 325,000	30,000 Sq. Ft.	$ 540,000
,200 Sq. Ft.	12,000	1,500 Sq. Ft.	15,000	2,100 Sq. Ft.	21,000	3,000 Sq. Ft.	30,000
-5T	60,000	1-7½T-80'	83,000	2-7½T	166,000	2-10T	200,000
-3T	19,000		128,000		192,000	30,000 Sq. Ft.	240,000
	15,000	1	20,000		30,000	2	50,000
-45"	6,000	1-65"	8,000	2-65"	16,000	3-65"	24,000
	10,000	Lump Sum	15,000		20,000	2	25,000
	10,000	3	18,000	3	18,000	4	24,000
		1-25/45	85,000		100,000	1	130,000
-3T	410,000	2-11"-15T	830,000	3"-15T	1,275,000	4-11'-15T	1,816,000
-5,000KVA	Included in D-1	2-7,500 KVA	Included in D-1	3-10,000 KVA	Included in D-1	4-13,000 KVA	Included in D-1
ump	9,000	Lump	20,000	Lump	30,000	Lump	40,000
ump	2,000	Lump	6,000	Lump	9,000	Lump	12,000
	10,000	Lump	20,000		25,000		30,000
	3,000	2	8,000	3	9,000	4	12,000
one	-	1-30T 600 KW.	325,000	2-40T 800 KW Ea.	700,000	2-60T 1200 KW Ea.	800,000
	-	1	115,000	1	125,000	1	145,000
	-	Lump	45,000	Lump	90,000	Lump	180,000
	$554,000		$1,726,000		$2,815,000		$3,778,000
	$ 19,000		$ 61,000		$ 99,000		$ 132,000
	$715,000		$2,036,000		$3,260,000		$4,480,000
	$ 36,000		$ 102,000		$ 163,000		$ 224,000
	$751,000		$2,138,000		$3,423,000		$4,704,000
	$ 75,000		$ 214,000		$ 342,000		$ 470,000
	$826,000		$2,352,000		$3,765,000		$5,174,000
	$330 165 82.50		$156.80 78.40 39.20		$62.75 31.38		$51.74 25.87

EQUIPMENT REQUIREMENTS

CORELESS INDUCTION FURNACES, WITH PREHEATERS, NO HOLDING FURNACES, AFTERBURNER ON PREHEATER

	5 TPH		
	Number and Size	Cost	Number and Siz
A. **Buildings**			
Melting Building $17/Sq. Ft.	5,000	$ 85,000	9,000 Sq.
Transformer Building $10/Sq. Ft.	1,000 Sq. Ft.	10,000	1,200 Sq.
B. **Scrapyard Equipment**			
1. Scrapyard Crane	1-5T	60,000	1-7½T-80'
2. Crane Runway	Open	19,000	Covered
3. Platform Scales		15,000	1
4. Magnets	1-45"	6,000	1-65"
5. Charge Bucket Transfer Cars & Track		8,000	Lump
C. **Charging Equipment**			
Charging Monorail		40,000	
D. **Melting Equipment**			
1. Coreless Induction Furnaces	2-10 Ton KW 2,100 Each	400,000	2-20 Ton 4,100 KW Ea
3. Preheater with Charge Bucket	1	28,000	2
4. Slag Box		2,000	
5. Piping, Headers, Sewer Connections		10,000	
E. **Holding Equipment** - None Specified			
Subtotal #1 (B + C + D + E)		$588,000	
F. Spares & Freight (3½% of B, C, D, E)		$ 21,000	
Subtotal #2 (ST. #1 + A + F)		$704,000	
G. Engineering (5% of ST. #2)		$ 35,000	
Subtotal #3 (G + ST. #2)		$739,000	
H. Contingencies (10% of ST. #3)		$ 74,000	
Total (ST. #3 + H)		$813,000	
Cost/Ton			
500		$325	
1,000		162.50	
2,000		81.25	
1,000			
2,000			
4,000			
2,000			
4,000			

A

APPENDIX D
NUMBER 42

EQUIPMENT REQUIREMENTS

CORELESS INDUCTION FURNACES, WITH PREHEATERS, NO HOLDING FURNACES, AFTERBURNER ON PREHEATER

5 TPH		15 TPH		30 TPH		50 TPH	
Number and Size	Cost	Number and Size	Cost	Number and Size	Cost	Number and Size	Cost
0	$ 85,000	9,000 Sq. Ft.	$ 153,000	13,500 Sq. Ft.	$ 230,000	20,000 Sq. Ft.	$ 340,000
0 Sq. Ft.	10,000	1,200 Sq. Ft.	12,000	1,800 Sq. Ft.	18,000	3,000 Sq. Ft.	30,000
	60,000	1-7½T-80' Span	83,000	2-7½T	166,000	2-10T	200,000
	19,000	Covered	128,000	Covered	192,000	Covered	240,000
						30,000 Sq. Ft.	
	15,000	1	20,000		30,000	2	50,000
"	6,000	1-65"	8,000	2-65"	16,000	3	24,000
	8,000	Lump	10,000		15,000	2	20,000
	40,000		50,000		60,000		75,000
Ton	400,000	2-20 Ton	850,000	3-25 Ton	1,600,000	4-30 Ton	2,200,000
,100 Each		4,100 KW Each		6,250 KW Each		6,750 KW Each	
	28,000	2	64,000	3	129,000	4	172,000
	2,000		5,000		7,000	4	10,000
	10,000		20,000		25,000		30,000
	$588,000		$1,238,000		$2,240,000		$3,021,000
	$ 21,000		$ 43,000		$ 78,000		$ 106,000
	$704,000		$1,446,000		$2,566,000		$3,497,000
	$ 35,000		$ 72,000		$ 128,000		$ 175,000
	$739,000		$1,518,000		$2,694,000		$3,672,000
	$ 74,000		$ 152,000		$ 269,000		$ 367,000
	$813,000		$1,670,000		$2,963,000		$4,039,000
	$325						
	162.50						
	81.25						
			$111.33				
			55.67				
			27.84				
					$ 49.38		$ 40.39
					24.69		20.20

B

DIRECT MATERIAL COST

	Cost per Pound	Lined Cupola			Water-Cooled C	
Metallics		Percent	Pounds	Cost	Percent	Pounds
Pig Iron	$.03326	5%	104	$3.46		
#2 Heavy Melting Steel Scrap	.01451	30	623	9.04	37	800
#1 Heavy Melting Steel Scrap	.01813	5	104	1.89	5	104
Borings-Briquettes	.01506	15	312	4.70	15	312
Borings-Loose	.00924	-	-		-	-
Iron Scrap-Remelt	.02121	34	706	14.97	32	706
Iron, Cast Scrap	.02121	10	208	4.41	10	208
Sil Mn. Briquettes	.1050	.40	8	.84	.40	8
Sil. Carb. Briquettes	.075	.40	4	.60	.40	8
Fe. Si. 85%	.1945	.20	4	.78	.20	4
Fe. Si. 50%	.1530	-	-		-	-
			2,077			2,150
Nonmetallics						
Coke	.02475		360	$8.91		250
Sil. Mn. Briquettes	.1050		1.5	.16		1.5
Carbo-Graphite	.04		8.5	.34		-
Soda Ash	.03		2.5	.08		2.5
Limestone	.00388		60	.23		60
Sil. Carb. Briquettes	.075		9	.68		9
Cost per Ton				$51.09		$

A

APPENDIX D
NUMBER 43

RECT MATERIAL COST

Water-Cooled Cupola			Electric Furnace			Induction Furnace		
Percent	Pounds	Cost	Percent	Pounds	Cost	Percent	Pounds	Cost
37	800	$11.61						
5	104	1.89	50%	1,045	$18.95	27	550	$ 9.97
15	312	4.70	-			15	302	4.55
-	-		15	300	2.77	-		
32	706	14.97	33	680	14.42	34	686	14.55
10	208	4.41	-	-		22	445	9.44
.40	8	.84						
.40	8	.60						
.20	4	.78	.4	8	1.56	.4	8	1.56
-	-		1.4	30	4.59	1.4	30	4.59
	2,150			2,063			2,021	
	250	$6.19						
	1.5	.16						
	-			60	$2.40		60	$2.40
	2.5	.08						
	60	.23						
	9	.68						
		$47.14			$44.69			$47.06

B

SUMMARY OF CONVERSION COS

CUPOLA, COLD BLAST NO HOLDING
FABRIC FILTER EMISSION CON

	Melt Rate 5 Tons Per Hour			Mel 15 T
	Operating Hours Per Year			Operatin
Costs Per Ton	500	1,000	2,000	1,000
Direct and Indirect Labor	$18.00	$16.00	$14.00	$ 8.67
Salaried Personnel	4.32	3.60	2.88	1.92
Depreciation	16.00	8.00	5.00	6.73
Capital Charges (Interest, Insurance, Taxes)	20.40	10.20	6.50	8.80
Electrical Power	.07	.05	.04	.05
Gas	.05	.05	.05	.05
Supplies and Maintenance Material	3.00	3.00	3.00	3.00
Allocated Costs	4.00	4.00	4.00	4.00
Total	$65.84	$44.90	$35.27	$33.22

A

APPENDIX D
NUMBER 44

OF CONVERSION COSTS

BLAST NO HOLDING FURNACE,
ILTER EMISSION CONTROL

	Melt Rate 15 Tons Per Hour			Melt Rate 30 Tons Per Hour		Melt Rate 50 Tons Per Hour	
r Year	Operating Hours Per Year			Operating Hours Per Year		Operating Hours Per Year	
2,000	1,000	2,000	4,000	2,000	4,000	2,000	4,000
$14.00	$ 8.67	$ 7.33	$ 6.36	$ 5.83	$ 4.58	$ 4.30	$ 3.35
2.88	1.92	1.92	1.44	.96	.72	.58	.43
5.00	6.73	4.07	2.03	3.50	1.75	2.87	1.44
6.50	8.80	5.30	2.65	4.55	2.28	3.73	1.87
.04	.05	.03	.03	.03	.02	.02	.02
.05	.05	.05	.05	.05	.05	.05	.05
3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
$35.27	$33.22	$25.70	$19.56	$21.92	$16.40	$18.55	$14.16

B

SUMMARY OF CONVERSION COST

CUPOLA, HOT BLAST, WATER-COOLED,
CHANNEL INDUCTION HOLDING FURNAC
ENERGY WET SCRUBBER EMISSION C

Cost per Ton	Melt Rate 5 Tons per Hour Operating Hours per Year 2,000	 4,000	Me 15 Ton Operating 2,000
Direct and Indirect Labor	$17.00	$15.00	$ 7.33
Salaried Personnel	2.88	2.16	1.92
Depreciation	5.07	2.54	4.43
Capital Charges (Interest, Insurance, Taxes)	6.59	3.29	5.76
Electrical Power	.05	.04	.62
Water	.20	.20	.20
Gas	.25	.25	.25
Supplies and Maintenance Material	2.00	2.00	2.00
Allocated Costs	4.00	4.00	4.00
Total	$38.04	$29.48	$26.51

A

APPENDIX D
NUMBER 45

OF CONVERSION COSTS

AST, WATER-COOLED, UNLINED,
TION HOLDING FURNACE, HIGH
SCRUBBER EMISSION CONTROL

	Melt Rate 15 Tons per Hour		Melt Rate 30 Tons per Hour		Melt Rate 50 Tons per Hour	
r Year	Operating Hours per Year		Operating Hours per Year		Operating Hours per Year	
0	2,000	4,000	2,000	4,000	2,000	4,000
00	$ 7.33	$ 5.83	$ 5.50	$ 4.41	$ 3.90	$ 3.10
16	1.92	1.44	.96	.72	.58	.43
54	4.43	2.22	3.60	1.80	3.24	1.62
29	5.76	2.88	4.68	2.34	4.21	2.11
04	.62	.40	.52	.33	.45	.29
20	.20	.20	.20	.20	.20	.20
5	.25	.25	.25	.25	.25	.25
00	2.00	2.00	2.00	2.00	2.00	2.00
00	4.00	4.00	4.00	4.00	4.00	4.00
8	$26.51	$19.22	$21.71	$16.05	$18.83	$14.00

B

SUMMARY OF CONVERSION COS

ELECTRIC ARC FURNACE WITH CHANNEL INDUCTI
FABRIC FILTER EMISSION CON

	Melt Rate 5 Tons Per Hour			Melt Rate 15 Tons Per H	
	Operating Hours Per Year			Operating Hours	
Costs Per Ton	500	1,000	2,000	1,000	2,000
Direct and Indirect Labor	$18.00	$14.00	$12.00	$7.66	$6.67
Salaried Personnel	4.32	3.60	2.88	1.92	1.92
Depreciation	33.04	16.52	8.26	15.67	7.84
Capital Charges (Interest, Insurance, Taxes)	42.95	21.48	10.74	20.40	10.20
Electrical Power	36.00	19.90	11.76	19.68	11.86
Water	.05	.05	.05	.05	.05
Gas	.05	.05	.05	.05	.05
Electrodes	2.85	2.85	2.85	2.85	2.85
Supplies and Maintenance Material	2.50	2.50	2.50	2.50	2.50
Allocated Costs	4.00	4.00	4.00	4.00	4.00
Total	$143.76	$84.95	$55.09	$74.78	$47.94

A

APPENDIX D
NUMBER 46

Y OF CONVERSION COSTS

ITH CHANNEL INDUCTION HOLDING FURNACE, FILTER EMISSION CONTROL

Melt Rate 15 Tons Per Hour			Melt Rate 30 Tons Per Hour		Melt Rate 50 Tons Per Hour	
Operating Hours Per Year			Operating Hours Per Year		Operating Hours Per Year	
1,000	2,000	4,000	2,000	4,000	2,000	4,000
$7.66	$6.67	$5.50	$5.33	$4.50	$4.10	$3.45
1.92	1.92	1.44	.96	.72	.58	.43
15.67	7.84	3.92	6.28	3.14	5.17	2.59
20.40	10.20	5.10	8.17	4.09	6.73	3.37
19.68	11.86	7.92	11.25	7.57	11.11	7.50
.05	.05	.05	.05	.05	.05	.05
.05	.05	.05	.05	.05	.05	.05
2.85	2.85	2.85	2.85	2.85	2.85	2.85
2.50	2.50	2.50	2.50	2.50	2.50	2.50
4.00	4.00	4.00	4.00	4.00	4.00	4.00
$74.78	$47.94	$33.33	$41.44	$29.47	$37.14	$26.79

B

SUMMARY OF CONVERSION CO

CORELESS INDUCTION FURNACE WITH CHA
NO HOLDING FURNACE, AFTERBURNER

	Melt Rate 5 Tons Per Hour			Melt Rate 15 Tons Per	
	Operating Hours Per Year			Operating Hou	
Costs Per Ton	500	1,000	2,000	1,000	2,00
Direct and Indirect Labor	$18.00	$15.00	$14.00	$ 8.00	$ 7.
Salaried Personnel	4.32	3.60	2.88	1.92	1.
Depreciation	32.52	16.26	8.13	11.13	5.
Capital Charges (Interest, Insurance, Taxes)	42.27	21.14	10.57	14.47	7.
Electrical Power	39.79	22.18	13.37	14.86	9.
Water	.05	.05	.05	.05	.
Gas	.30	.30	.30	.30	.
Supplies and Maintenance Material	3.00	3.00	3.00	3.00	3.
Allocated Costs	4.00	4.00	4.00	4.00	4.
Total	$144.25	$85.53	$56.30	$57.73	$38.

A

APPENDIX D
NUMBER 47

CONVERSION COSTS

RNACE WITH CHARGE PREHEATER, , AFTERBURNER ON PREHEATER

Melt Rate 15 Tons Per Hour			Melt Rate 30 Tons Per Hour		Melt Rate 50 Tons Per Hour	
Operating Hours Per Year			Operating Hours Per Year		Operating Hours Per Year	
1,000	2,000	4,000	2,000	4,000	2,000	4,000
$ 8.00	$ 7.00	$ 6.36	$ 4.84	$ 4.16	$ 3.90	$ 3.40
1.92	1.92	1.44	.96	.72	.58	.43
11.13	5.57	2.78	4.94	2.47	4.04	2.02
14.47	7.24	3.62	6.42	3.21	5.25	2.62
14.86	9.40	6.64	9.64	6.76	8.68	6.28
.05	.05	.05	.05	.05	.05	.05
.30	.30	.30	.30	.30	.30	.30
3.00	3.00	3.00	3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00	4.00	4.00	4.00
$57.73	$38.48	$28.19	$34.15	$24.67	$29.80	$22.10

B

ANNUAL OPERATING COSTS
FOR EMISSION CONTROL EQUIPMENT SYST

	5 Tons/Hour				15	
	500	1,000	2,000	4,000	1,000	
1. **Fabric Filter on Cupola (Cold Blast)**						
Number Cupolas	1	1	1		1	
ACFM Each	9,200	9,200	9,200		27,300	
Annual Operating Cost	$25,000	$30,000	$35,000		$60,000	$
Annual Tons	2,500	5,000	10,000		15,000	
Cost/Ton	$10	$6	$3.50		$4.00	
2. **Wet Scrubber on Cupola (Hot Blast)**						
ACFM			6,800	6,800		2
Annual Operating Cost			$35,000	$50,000		$6
Annual Tons			10,000	20,000		3
Cost/Ton			$3.50	$2.50		
3. **Fabric Filter on Electric Arc**						
Furnace Diameter	7'3"	7'3"	7'3"		11'	
Annual Operating Cost/System	$28,000	$31,000	$37,500		$41,000	$4
Number Fabric Filter Systems	2	2	2		2	
Total Annual Operating Cost	$56,000	$62,000	$65,000		$82,000	$9
Annual Tons	2,500	5,000	10,000		15,000	3
Cost/Ton	$22.40	$12.40	$6.50		$5.47	
4. **Afterburner on Coreless Induction**						
Annual Operating Cost	$1,150	$1,350	$1,730		$3,040	$
Tons	2,500	5,000	10,000		15,000	3
Cost/Ton	$.46	$.27	$.17		$.20	

A

APPENDIX D
NUMBER 48

NUAL OPERATING COSTS
ON CONTROL EQUIPMENT SYSTEMS

	15 Tons/Hour			30 Tons/Hour		50 Tons/Hour	
4,000	1,000	2,000	4,000	2,000	4,000	2,000	4,000
	1	1	1	2	2	2	2
	27,300	27,300	27,300	27,300 Each	27,300 Each	37,200 Each	37,200 Each
	$60,000	$70,000	$80,000	$140,000	$160,000	$180,000	$200,000
	15,000	30,000	60,000	60,000	120,000	100,000	200,000
	$4.00	$2.33	$1.33	$2.33	$1.33	$1.80	$1.00
6,800		22,800	22,800	43,000	43,000	62,000	62,000
$50,000		$60,000	$75,000	$110,000	$140,000	$165,000	$195,000
20,000		30,000	60,000	60,000	120,000	100,000	200,000
$2.50		$2.00	$1.25	$1.83	$1.17	$1.65	$ .98
	11'	11'	11'	11'	11'	11'	11'
	$41,000	$49,000	$64,000	$49,000	$64,000	$49,000	$64,000
	2	2	2	3	3	4	4
	$82,000	$98,000	$128,000	$147,000	$192,000	$196,000	$256,000
	15,000	30,000	60,000	60,000	120,000	100,000	200,000
	$5.47	$3.27	$2.13	$2.45	$1.60	$1.96	$1.28
	$3,040	$4,150	$6,380	$7,260	$11,640	$11,060	$18,280
	15,000	30,000	60,000	60,000	120,000	100,000	200,000
	$.20	$.14	$.11	$.12	$.10	$.11	$.09

B

EMISSION TEST PROCEDURES

A standard recommended procedure for testing particulate emissions from iron foundry cupolas did not exist until the end of 1970. At that time the "Recommended Practice for Testing Particulate Emissions from Iron Foundry Cupolas" was adopted by the American Foundrymen's Society and the Gray and Ductile-Iron Founders' Society, Inc. This industry standard procedure, broadly based on the American Society of Mechanical Engineers Performance Test Codes 21-1941 and 27-1957, recognizes the unique problems of cupola testing and recommends procedures to deal with them in a satisfactory manner. The recommended practice is reproduced in Exhibit 1 of this appendix for information purposes only.

In a more specific manner, Exhibit 2 presents detailed sampling and analytical techniques for individual components of cupola emissions. These techniques are widely accepted by chemical and testing laboratories and used in analytical work. Techniques are included for identification and quantification of particulate matter such as arsenic, beryllium, cadmium, fluorides, lead, mercury, and zinc, and two gaseous components, nitrogen oxides and sulfer dioxide.

APPENDIX E
EXHIBIT 1

RECOMMENDED PRACTICE FOR TESTING PARTICULATE EMISSIONS FROM IRON FOUNDRY CUPOLAS

Edited by

A Joint Committee of

American Foundrymen's Society

and

The Gray & Ductile Iron Founders' Society, Inc.

The recommended procedure discussed in this section has, as of this date, not been endorsed by any bodies other than A.F.S. and G.D.I.F.S. and is presented for information only.

INTRODUCTION

The iron foundry industry has had many air pollution studies conducted on cupola emissions at their various plants. Of great concern to the industry and to the individual firms that have conducted such testing are the many varied and diverse test methods and test procedures used by the variety of independent organizations conducting such tests. The diverse methods and equipment used in performing such tests have made comparison and evaluation of results impractical or a near impossibility. Many of the tests conducted have shown marked inconsistencies between individual test runs by the same test group and also in comparing the results on the same system by different testing organizations.

A number of the procedures used in cupola testing suffer from obvious inadequacies when they are carefully scrutinized. Consequently, it has been deemed desirable and necessary that a recommended test procedure and testing method be made available to assist the metalcasting industry in achieving the maximum in emission control with the minimum of wasted and misdirected effort and expense. Since the industry is unique in the large, nonproductive investments needed to gain compliance with air pollution control requirements, it is especially significant that its emissions be evaluated by test methods and procedures able to produce consistently reliable results detailing these emissions, but do not unnecessarily and unfairly penalize the plant.

Particulate emission tests of cupola stack gases are done under varied conditions and in several different locations, depending on the test objective. Both location and objective influence the test equipment employed although the two usual purposes will be:

1) to determine nature and/or quantity of emissions released in the raw cupola gases
2) to determine nature and/or quantity of emissions on the cleaned gas side of a control unit.

Raw gas test locations:

a) In cupola stack, above charging door. This is the most difficult location for testing. Gas flow is extremely uneven and the flow rate is relatively low; gas temperature is high - often 1200°-2200°F - and fluctuating; dust loading is extremely uneven because of channeling caused by indraft of much cold outside air drawn into the cupola stack through the charge door. This test location is necessary where a cupola has no control systems or has a wet cap type collector.

b) In inlet duct ahead of dust collector. This is an easier location if a reasonably straight duct run is available. Duct velocities and dust loadings are more uniform and confined in a smaller cross section. Normally gases will be cooled to 500°F or lower at the sampling point from evaporation of cooling water. The added volume of water vapor must be measured and considered in gas density calculations and dust loadings if reported in grains per standard cubic feet dry gas. Inlet and outlet samples should be supplemented wherever possible by using the catch as a check for the test data. Catch can be more readily obtained from dry collector types especially for a complete melting cycle.

c) Catch plus outlet loadings. Where dry collectors are employed, the entire test procedure is simplified by actual weighing of collected material. The higher the efficiency of the collecting device the more nearly the catch will represent the raw sample. Chances for error are diminished because of quantity of collected material available although it will be difficult to obtain accurate catch quantities except for a complete melting cycle - thus providing an averaging of the peaks and valleys of emission concentrations.

See comments for outlet loading under "Cleaned Gas Locations".

Cleaned Gas Locations:

a) After dry collector. Conventional dust sampling techniques will be satisfactory for such locations. Coarse particles will be removed by a dust collector so the importance of a large diameter sampling probe diminishes. Water vapor content of the gas should cause no condensation problems with 350° to 550°F gas temperatures. Collecting device in sampler can be influenced by intended analysis - gross weight, particle size distribution, chemical composition, particle count, etc.

b) After wet collector. Sampling problems are more complicated than after dry collectors because gas stream is saturated or nearly so. Close coupling of sampling components is essential and heating of the sampled air often required.
Exception: Wet cap type of collectors have too short a contact time to bring gas stream close to saturated conditions. Sampling after the collector will be questionable value unless gases are gathered in a discharge stack of several diameter lengths.

In recognition of these differences in purpose and location for testing emissions the following procedure is divided into three sections.

Section I deals exclusively with sampling raw particulate emissions in the cupola stack.

Section II deals exclusively with sampling raw particulate emissions in the inlet duct connecting the cupola to the dust collector.

Section III deals exclusively with sampling cupola gases after they have been cleaned.

REASONS FOR SAMPLING A CUPOLA

Basically sampling is done for three reasons:

1) to determine if a collecting device is of a high enough efficiency so that its effluent does not exceed a predetermined level.
2) to meet regulatory requirements that specify a minimum efficiency of removal of particulate from the gas stream, expressed as a percentage of uncontrolled emission.
3) to obtain information regarding particulate emission which will be used for designing gas cleaning devices.

Officials of local, regional or state regulatory bodies should be consulted prior to testing except when the testing is being done for purely informational data for the cupola owner or operator.

If source testing is being done to determine compliance with legal requirements the appropriate control officials should be consulted. If the control body has experience and is equipped to perform cupola testing, they may wish to perform their own tests to determine compliance.

Generally control bodies will not accept the results of tests performed by the owners, operators or vendors of collection devices unless standard procedures were followed and test data and reports show evidence that experienced personnel conducted the tests.

In most cases it will be necessary for the owner or operator of a cupola to employ the services of an organization capable of performing these tests. When this is done the control authorities should have given prior approval of the testing organizations capabilities and acceptability of their test results. In any event, it is advisable to notify the proper authorities in advance so that they may have on site observers present if they so desire.

The foundryman should select a testing organization with proven capability, a good reputation and in whom he has complete confidence. As test data can have major economic consequences and as the foundryman usually cannot check the quality of the testing procedures confidence in the organization is a prerequisite.

The next step is consultation with the appropriate control authorities. The foundryman along with the testing organization must involve themselves in this because regulations are sometimes not easily understood, and frequently interpretation is modified by political and community attitudes. Authorities will be aware of changes in enforcement policies, or pending changes in legislation, and the foundryman cannot expect outside testing organizations to be cognizant of these considerations.

The number and type of tests to be taken must be agreed on in advance by all parties concerned. Frequently, meeting the specifications of the pertinent code dictate the number and kind of samples to be run. At other times the purchase agreement between vendor and foundryman specifies testing methods. If discretion can be used the use of several short tests is recommended over one longer one. When several results can be compared, any large differences are evident. If these differences are not as a result of operational changes or adjustments they may indicate error in the test procedure or malfunction of the test equipment. One test of long duration gives only one answer with no basis for comparison. Accuracy and precision of testing is controlled as much by the care exercised and quality of the testing personnel as it is by the test procedure.

Errors in each manipulation such as weighing, measuring gas volume, and calculating results must not exceed 1 percent and should be kept under that if possible. In this way cumulative errors can be held to little more than 1 percent.

CUPOLA OPERATING AND TEST CONDITIONS

Due to the various possible modes of operation of cupolas and cupola systems, it is recommended that cupola emissions be evaluated under conditions that characterize normal or average cupola operations at any particular plant.

Particulate matter emitted via raw cupola stack gases consists principally of iron oxides and silica from the charge metal and impurities adhering to the charge metal plus combustible matter. Secondary combustion in the upper portion of a cupola stack will tend to reduce the combustible portion of the particulate emissions to ash if temperature and retention time are sufficient.

Cupola stack gas will also contain some vapor from substances which reaches the melting zone and is volatilized. These substances include silicon, zinc and silica (sand). The degree of volatilization will depend on melting zone temperature which is influenced by changes in the fuel (coke and/or gas) ratio, preheating of the blast air or scrap and enrichment of the blast air with oxygen. Consequently, it is of utmost importance that the factors affecting melt zone temperature be normal before testing begins. Equally as important, materials that can cause fuming, such as galvanized iron, sand, and silicon, for example, be added in normal amounts during the test period. Changes from normal melt process can result in emissions which are markedly better or worse than will be obtained during everyday operation. Either result will be unsatisfactory.

The particulate matter emanating from a cupola has a wide range of particle size distribution which influences the correct choice of stack testing method. For many cupolas, peaks in particle sizes can be found on distribution curves at three ranges. These are in the 200 to 500 micron range, the 20 to 50 micron range and the 5 micron and below range.

Many factors influence the particulate emission rates of a cupola system. These include the rate of cupola operation, the character, cleanliness and method of introduction of the charge material, the type, size and amount of the coke used, the frequency, length of time and number of periods when tuyere blast air is operative or inoperative during any period, the type of metal being melted, the method and type of alloy introduction, and other diverse factors.

It is necessary, therefore, that each cupola and cupola system be individually analyzed to determine conditions under which stack or source emission tests are needed to define the full range and character of its emissions.

One of the factors having a most profound effect in cupola emissions is the rate of cupola melting; as cupola blast air and coke input is increased to accommodate higher melting rates, cupola emissions increase significantly. It is important, therefore, that cupola source-emission tests be conducted at melting rates approaching the normal expected rate of cupola operation if the results are expected to characterize emissions for the system. Often times it is not practical to operate at maximum melting rates since melting rates must reflect current production and pouring schedules. It should be appreciated, however, that cupola charging and melting rates have a profound influence on cupola emissions.

If for any reason tests during either start-up or burn down periods are made such tests should be kept and evaluated separately from each other as well as all others.

If various metals are produced at various times from the same cupola (such as gray and cutile iron) it is desirable that the emissions be evaluated for each type produced if there is a difference in melting conditions. The melting conditions that would tend to require evaluation in terms of differences in emissions would be reflected by variations in blast air rates, coke rates and charge metal characteristics.

Prior to any field test period the testing firm should be consulted for recommendations as to the number of days and number of test runs to be conducted to define the full range of cupola emissions consistent with cupola operating practices and other pertinent considerations. It is important that the plant's full range of operations be evaluated consistent with the stated objectives of the emission test program.

OBTAINING MEANINGFUL TEST DATA

For short run jobbing cupolas, it is recommended that a minimum of three dustloading test determinations be conducted of cupola emissions as part of any emission study. A volumetric determination should be conducted for each of the three test periods. To make the emission data be the most meaningful it is necessary and desirable that detailed records be kept of cupola operating conditions concurrent with the emission studies.

The emission test program can usually be conducted in one to three days of field sampling by an experienced testing organization. The following minimum information is considered necessary in establishing and fixing cupola operating conditions. It is necessary that these cupola operating data be secured concurrently with stack emission studies:

1) Nature, weight and constituents of all cupola charges.
2) Number and time of all cupola charges made on the test date(s).

3) Cupola blast air record showing volume changes during test. Verify that records indicate volume introduced but not quantities diverted as a means of throttling.
4) Presence of, type, number, capacity and location of afterburners.
5) Existence of gas ignition in the stack.

Ample precedents exist for evaluating the emission performance of only one cupola in a bank of two cupolas that are operated on alternate days. This situation is particularly valid if both cupolas are of the same size, oerate from the same tuyere blast air supply, are used in the production of similar types of iron and are operated at the same approximate rates.

If there are marked variations or changes in the operation of a 2-bank cupola system, particularly with respect to the factors outlined above, it is recommended that each cupola be evaluated individually for its emission potential. The design of a single emission control system serving a dual bank of cupolas must be predicated on achieving conformance with regulations for the most severe conditions of cupola operation during the normal production part of the melt cycle. For the larger job-shop cupola-operators and for the production foundry it is recommended that a minimum of two days field testing of cupola emissions be conducted. This type of test program will permit the operation and evaluation of both cupolas in a two unit bank.

The cupolas themselves should be operated at normal melting rates during the test period. Test dates should be selected when foundry pouring schedules will permit normal operation.

It is not necessary to obtain a gas analysis to determine gas density from the cupola because the difference in weight between air and the combustion gases is insignificant for exhaust volume calculation purposes.

SAMPLING PROCEDURES AND EQUIPMENT

A major problem in sampling and analysis is that high accuracy and precision must be obtained in a working foundry, where conditions are not conducive to laboratory-type manipulations. To achieve effective installation and operation of a sampling train in a foundry requires someone who is not overly worried with minute detail. On the other hand, when the critical analytical measurements and manipulations are made, the greatest attention to cleanliness, accuracy, and detail is required.

The sampling equipment required for this work must fit the same pattern. It must be simple, rugged, and yet capable of high accuracy. In general, it must be highly portable. Reliable equipment is available from several vendors, and all qualified testing groups have their own.

a. Filtering Media

A good filtering medium is a prerequisite to accurate sampling. Efficiency of collection must be at least 99 percent for all particulates encountered. An ideal filter medium should be very light so that accurate weight differences can be obtained from small samples. The filter should also be strong and resistant to both heat and moisture.

No medium available has all these properties so a compromise must be made. Readily available media and some of their characteristics are listed below. Reliable suppliers will give the characteristics of their products on demand.

FILTER PAPER

Conventional filter paper, made from cellulose, comes in hundreds of grades; most of them are not suited to fine particulate filtration, but some are specially designed for this service. They have good mechanical strength, good resistance to moisture, and reasonable heat resistance. Conventional paper must be dried and desiccated before each weighing, and must weighed on a balance from which moisture can be excluded. Ideally the paper should be allowed to reach equilibrium in a constant-humidity room, and should be weighed there.

GLASS FIBER FILTER PAPER

Glass fiber filter paper will withstand higher temperature than conventional paper, but it should be remembered that a plastic binder is used in the manufacture of most of this paper and that the binder lowers temperature resistance. Some paper is made without binder and this is much more resistant to temperature. However, this material lacks mechanical strength, and the unbonded variety is particularly weak. Glass fiber filter paper has the great advantage that it is not sensitive to humidity and so can be used where a dessicator is not available.

THIMBLES

The Soxhlet thimble has been used widely in the past. The thimbles are made of two materials, paper and ceramics. The paper thimbles have the same strengths and weaknesses as ordinary paper, and the same precautions apply. The ceramic ones come in a variety of porosities. If the pores are small enough for this work, rates of filtration will be extremely small. In addition, ceramic thimbles are very heavy so that large samples must be weighed to obtain accuracy. Thimbles of any type are not recommended for this work.

A variety of cloth materials are used for filtering particulates. Usually efficient filtration results only after a coating of particulate has been built upon the cloth. This buildup occurs most rapidly when the sampled gases contain large amounts of particulate, hence sampling error is minimized.

When particulate loading is low, such as when sampling cleaned gas, significant error can be introduced unless the fabric is 99 percent efficient on the first material that deposits.

b. Weighing

The first steps in sampling is weighing the filter paper, or other medium. Each paper should be marked with a number before weighing. The common practice of writing the weight on the paper after it has been obtained creates an error equal to the weight of the ink used. Much larger errors can result from the handling required to write on the paper. Lastly, and most importantly, the practice is poor technique, and, if allowed, will encourage other slovenly practices. The atmosphere in an ordinary analytical balance can be dried to some extent if a small beaker of concentrated sulfuric acid or container of silica gel is placed inside and the doors are kept closed.

If filter papers are weighed on one balance initially, and on a second when loaded, the second balance should be checked for consistency with the first. This can best be done by checking the weight of pre-weighed paper, and applying a correction if required. Accuracy on the total weight is not vital, but the difference between initial and final weights, which represents the weight of the sample, is critical.

c. Flow Measuring

Volume flow rate measuring devices must be preceded by system components to minimize the surging or pulsating effects normal in cupola operation and sampling. The use of flow rate measuring devices in testing effluents from a dynamic system, such as a cupola, requires that frequent readings be taken (2 or 3 minutes reading cycle should be the maximum time period between readings) and that all readings must be conducted on a stopwatch timed basis.

It is recommended that sampling volume flow rate measurements be taken using two different flow measuring mechanisms in any high volume sampling train. The average of the two sampling volume rate measurements and computed sampling volumes should then be used in the subsequent dustloading calculations.

d. Flushing the Sampling Train

At the end of each dustloading test run it is imperative that the sampling train (nozzle, connecting tube or hose and sampler) be thoroughly cleaned and flushed. Distilled water should be used and introduced into the nozzle at high velocities to aid in scrubbing the sampling train.

The particulates flushed from the sampling train should be handled, weighed and separately determined. Significant quantities of particulates are deposited in any sampling train, so it is important that this material be included with the sampled catch when computing the dustloading test results.

e. Velocity-Volumetric Tests

An S-type pitot tube is preferred to a regular pitot tube because it is not as prone to plugging. Stainless steel, Iconel or other high temperature resistant material should be used in the pitot tube construction. A ruggedly constructed inclined draft gage is recommended for use in the velocity and dustloading tests. The pitot tube should be checked and calibrated according to the manufacturers recommendations at regular intervals to establish the proper correction factor to be used in the volumetric calculations.

f. Sampling Trains and Sampling Equipment

Few emission sources offer the trying field test conditions attendant to sampling as do cupola systems. The need also cannot be emphasized enough for rugged field sampling equipment for this testing. A schematic diagram of sampling apparatus for the static balanced tube method of sampling, incorporating recommendations for cupola effluent source emission sampling is presented in Fig. 1.

A possible commercial source for various components of the sampling train is indicated in Table 2. This is not to be construed as an endorsement of any particular manufacturer but is illustrative only of the rugged type of test equipment recommended for cupola source sampling.

When assembling sampling equipment, joint sealing materials should not be exposed to the sampled gas stream where adherence of the particulate could occur. Long-radius bends should be used instead of elbows to facilitate cleaning. The probe should be just long enough for the task at hand. The rest of the train should be assembled and tested for leaks. If the meter is a dry gas meter, it is to be calibrated before each use. If an orifice meter, or flow-meter type, is used it must also be calibrated each time, and it must, in addition, have enough sensitivity so that readings can be read to less than 1 percent. Finally, if volume is obtained by multiplying an instantaneous reading by the time of operation, fluctuations must be kept to 1 percent.

The vacuum pump or compound air ejector must be the last element of the sampling train unless it can be proved that there is no leakage through the packing, etc., under the worst conditions that can be visualized.

g. Analysis of Captured Particulate

It is recommended that the procedure for weighing and determining size distribution of the captured particulate be used as stated in the ASME PTC 27-1957 Section 4 Paragraphs 75-79 (see Appendix).

Fine particulate matter should be sized and analyzed within 24 hours after the sample is taken to minimize agglomeration and a possible change in character. It is most desirable if the sample is dried immediately after the test has been run to prevent degradation.

The minus 44 micron fraction of the collected particulate must be carefully handled and analyzed because of the strong tendency to agglomerate.

SECTION I - SAMPLING RAW PARTICULATE EMISSIONS IN THE CUPOLA STACK

Recommended Test Method and Procedures

A thorough and complete review of the available test methods and procedures used in the conduct of source emission studies has resulted in the recommendation of the following basic requirements as essential to an acceptable evaluation of the test methods:

1) In order to obtain a truly representative sample of coarse particulates from the gas stream a large volume sampling train should be used. The sampling nozzle should be constructed of stainless steel having a minimum inside diameter of 3/4 inches, since raw cupola emissions cover a broad range of particle sizes, with individual particles not uncommonly ranging up to 3/8 inch diameter or larger.
2) Particulate matter is defined consistent with the definition accepted by the dust collection industry and as adopted in the American Society of Mechanical Engineers Performance Test Code 21-1941, Dust Separating Apparatus and Performance Test Code 27-1957, Determining the Dust Concentration in a Gas Stream. See item 1 in the Appendix. In essence, this defines particulate matter as all filterable solids present at standard temperature in an effluent gas stream.
3) It is necessary that a truly "isokinetic" sample of gases and solids be secured by the sampling system. This requirement is a practical consideration dictated by the wide range of

particle sizes involved and, therefore, the special need for securing a truly isokinetic sample of the effluent solids.

4) When sampling in the cupola stack, water-cooled corrosion-resistant, sampling probes and sampling nozzles are required. This is a practical requirement since cupola temperatures in excess of 1200°F are common, and sample contamination by corrosion products formed in the nozzles and probes of the sampling system must be prevented. Water-cooling also serves to preserve the sampling probes from deterioration and distortion.

5) The American Society of Mechanical Engineers Performance Test Code 27-1957, Determining Dust Concentration in a Gas Stream, with modifications as outlined below offers the best and most practical test method and test procedures for the conduct of source emission studies from cupolas. The following are additional important considerations in the sampling of cupolas and cupola systems when utilizing as a broad base the test procedures and techniques embodied in ASME PTC 27-1957, Determining Dust Concentration in a Gas Stream. See item 2 in the Appendix. The criteria supplement the methods and procedures contained in ASME PTC 27, when applied to cupola source emission testing:

a. Test Location and Test Openings

A test location in a cupola stack must at best be a compromise. The location should be as far above the top of the charge door opening as practical but be at least one equivalent cupola inside daimeter below the top of the cupola stack. This location will require that protective shelter be provided since test personnel and equipment may be subjected to possible fallout of particles.

Test ports should consist of two six inch pipe nipples (schedule 40) installed radially in the cupola shell and cupola lining at 90 degrees to each other. Both 90 degree test ports must be accessible from the sheltered test platform. Six-in test ports are usually required to accommodate high volume sampling nozzles. An acceptable test platform can usually be constructed using temporary steel scaffolding. Corrugated metal sheeting can be used for the roof of the test platform. The six-inch pipe nipple test ports should protrude out a few inches from the cupola shell and should be flush with the inside of the cupola lining. The test port nipples should be fillet-welded to the cupola shell. The threads of the pipe nipples should be graphited and six-inch pipe caps installed hand tight so that they can be readily removed during the test period.

b. Method of Subdividing Cupola Stack

The cupola stack cross-sectional area should be measured at the test elevation. Due to refractory erosion and/or the buildup of slagged deposits which affect the cupola cross section, it is important that the cupola cross section and cross sectional area be determined at the test elevation. The ASME PTC 27 test code prescribed procedure (see item 2 in Appendix) should be followed in determining the location of the test points to be used in both the volumetric or pitot tube traverses and during the test runs.

A minimum of 12 points should be used as sampling locations in traversing a cupola stack in the dustloading test runs. Additional sampling points should be used when the maximum to minimum velocity variation in the velocity profile approaches, or exceeds, a 2 to 1 figure.

It is important that dust sampling be conducted at each test point and that the dustloading test-data sheet reflects the sampling conditions at each test point in traverse of the cupola from each test port. The practice of using a much smaller number of test points during the dustloading test runs, as compared to a large number of points used in the velocity checks, is almost certain to bias the test results and cause the results to be of a questionable nature with respect to securing a representative cupola sample.

c. Number and Duration of Test Runs

Test runs shall consist of a minimum of 60 minutes actual dust sampling. Based upon a minimum of 12 points of dust sampling of the cupola cross section from the two 90 degree test ports, an acceptable minimum sampling schedule would consist of sampling for 5 minutes at each of the 12 points. The field test data sheets and the test report must clearly reflect the location and the time of sampling at each of the sampling points used. A minimum of three sets of flow, temperature and pressure readings should be taken at each sampling point. The field data shall be logged and should reflect the dynamic conditions of cupola flows and sampling rates at each test point.

Readings of sampling flow rates, temperatures, pressures, gas analyses and other pertinent test data which are part of each dustloading test run should be taken on a 2 (maximum 3) minute cycle at each sampling point during each dustloading test run. The total sampling program should be conducted under stopwatch timing precision.

Three dustloading test runs and 3 velocity-volumetric test runs should be conducted in a single day of field sampling, as previously mentioned.

d. Sampling Probes

Sampling probes used in the dustloading test runs of raw gas should be of water-cooled, stainless steel construction. The sampling probes should be a minimum of 3/4 inch inside diameter, and preferably of larger inside diameter for tests conducted on raw gas emissions. Conventional smaller diameter test probes are suitable for use on the downstream side of dust collectors, but should not be used in raw gas sampling.

Either a standard or null type probe may be used for sampling raw cupola gases. Whichever probe is employed, a truly isokinetic sample must be taken at all test points during all test runs.

A null sampling probe of either the balanced static pressure type or balanced impact pressure type can be used. Null type probes are prone to introduce minimum error as their diameters increase and as the velocity of the flow system increases.

A null sampling probe must be calibrated and of such a size as to give the minimum sampling error (deviation from isokinetic) for the expected sampling velocity range.

Either type probe presents certain shortcomings which must be compensated for under the adverse, dynamic and widely varying flow conditions attendant to normal cupola operation.

Cupola velocities can be expected to range from 600 to 2400 ft/min. depending upon the size of the cupola and the rate of cupola operation. Normal operating velocity ranges can be expected to be 1000 to 1800 ft/min.

Fixed rate sampling trains, based upon an occasional velocity determination made at some fixed time, are unacceptable for cupola source sampling since such methods completely ignore the dynamic nature of the cupola melting process.

e. Filter Media

Due to the need for a large diameter sample probe and the necessity of isokinetically sampling the gas stream, a high volume sampling train is mandatory. The filtering media used for removing particulate from the gas stream must be of sufficient size to maintain the sampling rates necessary without imposing undue pressure drop restrictions on the sampling train.

The advantages and disadvantages of some of the various filtering media that can be used in removing the particulates from the sampled gas stream are stated in ASME PTC 27 Section 4 Paragraph 59 (See Appendix).

FOOTNOTE: Cloth is often used as the filtering media because of its high collection efficiency, good flow permeability, ability to be shaped or adapted to any sampler configuration, and freedom from plugging or excessive pressure buildup under minimum condensation conditions.

In the event that a cotton sateen fabric is selected it must be thoroughly washed and rinsed prior to use to be free of starch and sizing materials. This filter medium has as its most serious limitation a humidity or moisture pickup tendency. This problem can be adequately dealt with by proper and skilled weighing and handling techniques using an enclosed single pan desiccated analytical balance.

Sampler units housing the filter medium should be made or lined with corrosion resistant material and must permit ready and free insertion and removal of the filter medium. Sampler units must consist of airtight enclosures to ensure that all sampled gases pass through the filter medium, be capable of easy field cleaning and of conserving the sampled dusts with a minimum of sample loss in filter handling.

To facilitate transfer of collected material and prevent the possibility of incandescent particles from contacting the final filter medium it may be desirable to incorporate a small stainless steel cyclonic collector ahead of the ultimate filter medium. Such cyclones tend to remove the larger particulates and prolong the sampling period before the pressure buildup on the filter medium restricts isokinetic sampling, due to reduced sampling flow rate capability.

Such cyclones offer the additional advantage of providing a convenient method of measuring the gas sampling flow rate. This can be accomplished by calibrating the pressure drop across the cyclone collector unit entailing the measurement of the pressure differential across the cyclone, the temperature and the static pressure at that location.

FOOTNOTE: Scrubber (impinger) or condensing systems are considered unsatisfactory for particulate filtration in cupola sampling trains. Such systems promote and cause the formation of reaction products which were not present in the cupola gas stream. Since most available impinger or wet collecting apparatus, are associated with low volume sampling rates (not to exceed 1.0 cfm), it can be seen that they do not lend themselves well to high volume rate sampling without the use of multiple, parallel units.

While it may be of interest in some instances to determine if condensible material is present in cupola effluents such determinations are beyond the scope of this recommended practice for particulate.

When a gas analysis is desired it is recommended that a continuous carbon dioxide and/or a continuous oxygen analyzer be used to measure these gas constituents. Periodic checks can also be made using an Orsat gas analyzer to verify the performance of the continuous gas analyzer or to check on the total gas composition (CO_2, O_2, CO, N_2). The continuous gas analyzer should be read on a two or three minute cycle throughout each test run and the time noted. Results of each Orsat gas analysis conducted should be clearly indicated on the field data sheets and in the test report.

Sulfur oxide emissions from cupola systems are of such a low order that it is usually unnecessary to measure them in light of present day standards.

f. Sampling Volume Flow Rate

The need for a high volume sampling system to secure representative samples from cupola raw gas effluents often mitigates against the use of an integrating gas meter for measuring the sample gas volume although such are available to handle the flow ranges covered by 3/4 to 2 inch inside diameter dust sampling nozzles. However, portability requirements for such meters leave much to be desired and adverse field conditions in cupola sampling often preclude the use of such meters.

Sampling volume flow rate measurements can be made by flowrator systems, calibrated pressure drop mechanisms such as orifices, venturis or other similar flow measuring devices.

SECTION II - RAW GAS TEST LOCATION IN DUCT AHEAD OF COLLECTOR

Tests are often conducted to determine performance of collectors installed for cupola gas cleaning. Often a sample location in the connecting duct will have advantages over that of a cupola stack location because -

1. Gases will be cooled, usually by evaporation of water, to temperatures below 500°F.
2. Location more accessible.
3. Dustloadings and gas velocity more uniform thru cross section of sampling area.

   (Duct velocities usually in teh 3000 - 5000 fpm range.)

   In such locations:

   a. Number of sample points can correspond to ASME PTC 27 and need not be the minimum of 12 recommended for the cupola stack.
   b. Gas volume will include substantial proportion of water vapor and influence gas density.
   c. Some dust, especially of the coarser fractions, can bypass the sample area if there is substantial run-off of cooling water or for dust fallout in cooling towers, external combustion chambers, etc.

Whenever possible, catch from collector should be obtained and checked against calculated collected quantity from inlet and outlet samples. It is often difficult to get a sample covering only the test period, but often feasible to obtain quantity collected during a complete melting cycle. In the latter case, daily average data can be compared to short test runs of the sampling equipment.

Comparison of coarse fraction in the catch with the quantities reported by sampling will also give an indication of effectiveness of the sampling technique of such fractions. When indicated, catch from the collector needs to be augmented by inclusion of fallout in preceding system elements as noted in Item c.

SECTION III - SAMPLING CLEANED CUPOLA GASES

General

Sampling behind a gas cleaner alleviates some of the problems experienced when sampling raw cupola gases. Extremely large particles are no longer present permitting the use of conventional 1/4" or 3/8" diameter sampling probes and lower sampling volumes. The violent velocity fluctuations experienced in a cupola stack have been moderated; and the high temperatures of raw cupola gases have been reduced. On the other hand, a different problem is accentuated. Gas cleaning equipment is expensive, and is usually sold to meet a specified emission standard. Since performance curves for emissions become asymptotic, small changes in performance can cause large expenditures in equipment alteration, therefore accuracy of testing becomes more critical.

Because the gas sampled is hot and humid, the probe or filter holder must be heated to stop condensation on the walls of the apparatus from occuring. Such condensate will interfere with the filtration of particulate.

Cupola off-gases are almost always cooled by direct contact with water, so it can be a-sumed that they are humid after they have passed through a cleaning device, whether a wet scrubber or not. Consequently, a condenser must be inserted in the filtering train. This serves two purposes. First, it removes excess water which may condense and damage the gas meter. Secondly, and of vital importance, a condenser gives assurance that the gas passing through the train is saturated at an identifiable point. This provides the basis for exact calculation of the volume of dry gas metered, converted to standard conditions.

An acceptable procedure for testing is "Determining Dust Concentration in a Gas Stream", PTC 27-1957, published by the American Society of Mechanical Engineers.

While isokinetic sampling is not as critical for cleaned gases because of the small particle sizes involved, its use is recommended, following the same procedure of test locations, sample time, pitot traverse and data log recommended in Section I and II.

APPENDIX E
EXHIBIT 1
Figure 1

SCHEMATIC DIAGRAM OF SAMPLING APPARATUS

STATIC BALANCED TUBE METHOD OF SAMPLING

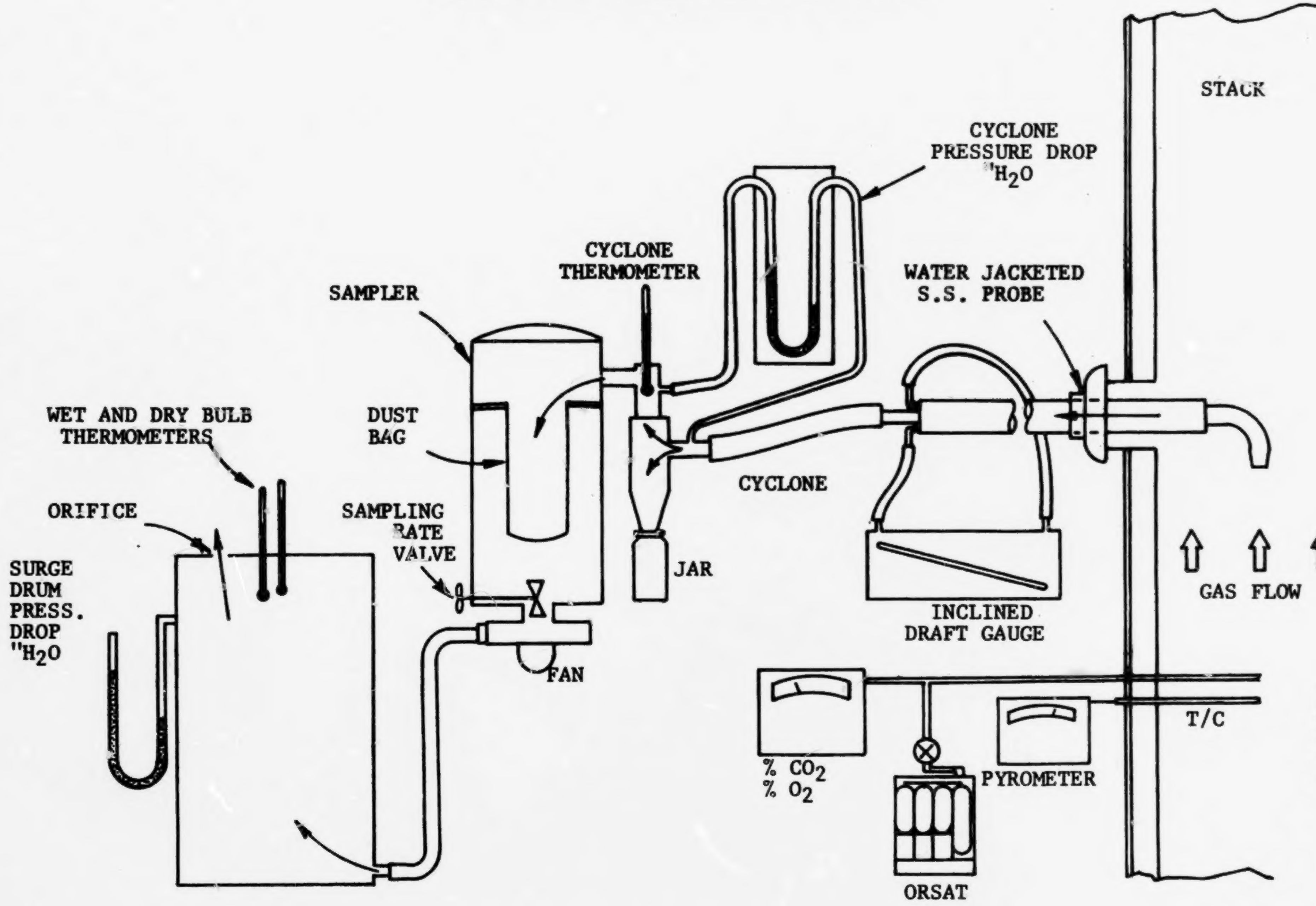

STACK
CYCLONE PRESSURE DROP "H_2O
CYCLONE THERMOMETER
SAMPLER
WATER JACKETED S.S. PROBE
WET AND DRY BULB THERMOMETERS
DUST BAG
CYCLONE
ORIFICE
SAMPLING RATE VALVE
JAR
SURGE DRUM PRESS. DROP "H_2O
GAS FLOW
INCLINED DRAFT GAUGE
FAN
T/C
% CO_2
% O_2
PYROMETER
ORSAT

TABLE 2 - REPRESENTATIVE SOURCES OF COMMERCIALLY MANUFACTURED COMPONENTS

	Component	Source
1.	Stainless steel, water-cooled static balanced, tube sampling nozzle-3/4 in. minimum ID.	Individually designed and constructed to meet nozzle diameter and probe length needs. Fitted with 6 in. pipe cap and pipe sleeve. Nozzles are to be calibrated to effect isokinetic sampling with minimum sampling error at the optimum velocity range for each different probe diameter. An acceptable nozzlehead design is schematically illustrated in ASME PTC 27 (Fig. 2).
2.	Inclined draft gage and holder, pitot tube.	Industrial Engineering Instrument Co., Allentown, Pennsylvania
3.	Stainless steel cyclone	UOP Air Corrections Division Darien, Connecticut
4.	Sampler	Fabricate to meet filter media confinement and handling requirements.
5.	Manometer	The Meriam Instrument Co., Cleveland, Ohio
6.	Thermometer	Weston Electrical Instrument Corp., Newark, New Jersey
7.	Industrial exhauster	Clements Manufacturing Co., Chicago, Illinois
8.	Continuous gas analyzer	Thermco Instrument Corp., LaPorte, Indiana
9.	Orsat gas analyzer	Hayes Corp., Michigan City, Indiana
10.	Pyrometer and thermocouple	Alnor Instrument Co., Division Ill. Testing Laboratories, Inc. Chicago, Illinois

APPENDIX E
EXHIBIT 2

SAMPLING AND ANALYTICAL TECHNIQUES

INTRODUCTION

Sampling and analytical techniques for the determination of emission rates from industrial processes have been standardized for many specific particulate and gaseous materials. The techniques described in the following paragraphs are those most widely used in the testing of iron foundry emissions testing. The format and wording for most procedures correspond to the source indicated for each procedure.

SAMPLING TECHNIQUE

Scope

The primary objective of stack testing is to determine the nature and/or quantity of emissions being released into the atmosphere. Sampling procedures that follow are applicable to the cleaned gas side of the control unit.

Apparatus

The accuracy of emission testing results is dependent upon qualified personnel conducting the test and the use of the proper apparatus for the material to be collected. Figure 1 illustrates information on sampling locations and apparatus most commonly involved in stack testing.

Sampling Principles

The location and number of sampling points are based on size and shape of the duct, uniformity of gas flow in the duct, availability of an adequate sampling port, and the space required to set up the equipment. Unfortunately, ideal conditions are seldom found in field testing and agreement on these factors must be reached before conducting the test.

To insure constancy of test conditions and results, complete information must be developed as to continuous or cyclic operation; nature, weight and composition of materials; gas volume and fluctuations; pressure; temperature and humidity; presence of other devices such as afterburners; and related conditions affecting the operation and equipment. These factors will regulate the time, number and duration of test runs.

Stack Gas Velocity

To determine particulate concentration in an exhaust stack, isokinetic source sampling must be used. This is the condition that exists when the velocity in the nozzle of the sampling tube is exactly the same as that in the stack. Isokinetic sampling is not mandatory when only gaseous substances are to be assayed.

In isokinetic sampling, the traverse area of the duct must be divided into equal areas and a pitot traverse taken. The use of the S-type pitot is recommended where particulates are involved to avoid any possibility of partial plugging and faulty readings. The velocity at each point must be calculated, and the volume of flow required to maintain that velocity in the sampling tip should volume fluctuate. Provisions must be made so that the volume can be recalculated immediately each time the pressure changes at the meter. However, when sampling is downstream from a gas cleaner, the volume is controlled by the system's fan and remains relatively constant and this procedure may not be necessary.

Detailed procedures on conducting velocity measurements are given in Bulletin WP-50 of the Western Precipitation Company, ASME Performance Test Code 27-1957 and the Industrial Ventilation Manual of the American Conference of Governmental Industrial Hygienists.

Concurrent with conducting the pitot traverse, it is essential to determine the temperature of the stack gas. The measuring device will be dependent on the temperatures involved.

Sample Probe

In assembling the sampling probe, teflon tape should always be used instead of pipe dope to prevent adherences of particulates. Long radius bends should be used instead of elbows to facilitate cleaning. The probe should be just long enough for the task at hand. The rest of the train should be assembled and tested for leaks.

Temperature and Humidity

If the gas sampled is hot and humid, condensation may occur in the probe or in the filter holder. The probe or filter holder must be heated to stop condensation from occurring because the water formed will trap water on the walls of the apparatus and will interfere with the filtration of particulates. Temperature control baths may be required for gas absorbers. In some cases the probe can be provided with a water cooling jacket.

Condensation

A condenser in the sampling train is required if the gas is humid. This serves two purposes. First, it removes excess water which may condense and damage the gas meter. Second, and of vital importance, a condenser gives assurance that the gas passing through the train is saturated at an identifiable point. This provides the basis for exact calculations of the volume of dried gas metered and conversion to standard conditions.

Collection Devices

The characteristics of the material in the stack will determine the collection method required. Dry filter mediums, of a variety of types, are most commonly used for particulate matter. Although in some cases the wet impingement method followed by a thimble is used. Gases are collected in absorbers with a proper absorbing solution. Grab sample units are available for spot sampling.

Flow Meters

If a dry gas meter is used, it must be calibrated before each use. If an orifice meter, or flow-type meter, is used it must also be calibrated each time, and it must have enough sensitivity so that readings can be obtained to less than one percent. Finally, if volume is obtained by multiplying an instantaneous reading by the time of the operation, fluctuations must be kept to one percent.

Vacuum Source

A vacuum source is required to draw the sample from the stack through the sampling train. A variety of pumps or ejectors are available for this purpose. Their capacity must be sufficient to draw the gas through the sample train at the required volume. The range is from one liter to several cubic feet per minute.

Sampling time will be dependent upon the factor of obtaining a representative sample of the operation. It may vary from several long continuous integrated samples of 30 to 60 minutes or a number of short samples of 5-10 minutes.

ANALYTICAL PROCEDURES

Introduction

Analytical procedures for a number of materials are given in the sections that follow. All calculations must be according to standard procedures and the standard conditions of temperature at 70 degrees Fahrenheit and an atmospheric pressure of 29.92 inches of mercury.

Particulate Matter

(a) Scope

The definition of particulate matter accepted by the dust collection industry is given in the ASME Performance Test Codes 21-1941 and 27-1957. In essence, this defines particulate matter as all filterable solids present at standard temperature in an effluent gas stream.

(b) Auxiliary Apparatus

- Filter Media - Efficiency of collection must be at least 99% for all particulates encountered and must be resistant to both heat and moisture.
- Balance - Macro analytical balance or equivalent.
- Drying Oven - Suitable for drying filters for about 5 hours at 105° C.
- Desiccation - To retain dried filters before weighing.

(c) Sampling Procedure

The first step in sampling is to prepare the filtering medium. An identification number should be provided for each filter and recorded on a separate data sheet. Prior to weighing, the filter should be dried for about 5 hours at about 105° C and then weighed immediately. This weight should be recorded on the data sheets and not on the filter. In order to keep weighing errors at a minimum, careful handling of the filters is required.

Preferably the pitot traverse, temperature and humidity readings should be taken not more than one-half hour before sampling is begun. Assemble the sampling train as shown in Figure 1 and proceed with the sampling by inserting the probe into the test stack. Continual observation of the sampling train during the entire sampling period is required to record any changes in pressure, temperature and airflow. This information, along with barometric pressure, sampling time and rate, is recorded on the sampling data sheet. Complete information on the process should also be noted on the sampling data sheet.

Length of the sampling time, at any specific point in the stack, will be contingent upon changes, if any, in the process or fluctuations of air volume. The sampling time should at least cover a complete cycle and will vary from 30-60 minutes. If airflow is not uniform in the stack, 5- to 10- minute samples at each of the traverse points should be obtained. Samples taken during start-up and burn-down periods should, as a rule, be considered separately from those taken during the production cycle of the cupola.

After a run is completed the probe must be cleaned of retained particulate matter. An acceptable procedure is to brush with a long flexible brush while the sample train is pulling in clean air. For other contaminants, follow procedures, if any, indicated for the specific material.

(d) Sample Preparation

Collected samples should be dried and placed in a desiccator to reach equilibrium before weighing. The difference between the original weight and final weight is the total amount of particulate matter collected.

(e) Calculations

The total particulate matter collected is expressed in grams. From this value, calculations can be made to express the findings in grains/SCF, pounds/hour, or pounds/1,000 pounds of gas, using the following constants:

One (1) gram = 15.43 grains
One (1) pound = 7,000 grains
One (1) gram = 0.002205 pounds
One (1) standard cubic foot of air = 0.075 pounds

1. Grains/SCF

$$\text{Grains/SCF} = \frac{(\text{Grams})\ (15.43)}{\text{Total SCF sampled}}$$

2. Pounds/Hour

$$\text{Pounds/hour} = \frac{60\ (\text{grains/SCF})\ (\text{total gas volume to atmosphere - SCFM})}{7{,}000}$$

3. Pounds/1,000 Pounds Gas

$$\text{Pounds/1,000 Pounds gas} = \frac{(\text{grams})\ (2.205)}{(0.075)\ (\text{total SCF sampled})}$$

Arsenic

Source: American Conference of Governmental Industrial Hygienists.

(a) Scope

Stack sampling for arsenic is based on the reaction of arsine with silver diethyldithiocarbamate. The amount of arsenic, in the air sample, is read directly from the calibration curve.

(b) Auxiliary Apparatus

- Greenberg-Smith Impinger.
- Beckman DU Spectrophotometer with photomultiplier or equivalent
- Arsine Generator (See Figure 2)

(c) Reagents

Silver Diethyldithiocarbamate - a cooled solution of silver nitrate (1.7 g in 100 ml distilled water) is added to a cooled solution of sodium diethyldithiocarbamate (2.25 g in 100 ml distilled water). The lemon yellow precipitate is filtered off, washed thoroughly with distilled water and dried in a vacuum desiccator below 20° C.

Pyridine - Mallinckrodt reagent grade pyridine is passed through an alumina column 1 inch in diameter and 6 inches in depth, at the rate of approximately 150 ml per hour. This process may remove a considerable quantity of colored material.

Arsine Absorbing Solution - Dissolve 1 g of silver diethyldithiocarbamate in 200 ml of chromatographed pyridine and filter the solution.

Hydrochloric acid - Baker's analyzed, specific gravity 1.19.

Potassium Iodide Solution - Dissolve 15 g reagent grade potassium iodide in 100 ml distilled water.

Stannous Chloride Solution - Dissolve 40 g stannous chloride dihydrate in 100 ml hydrochloric acid.

Zinc - Baker's analyzed; granular 20 mesh.

Lead Acetate - Dissolve 10 g reagent grade lead acetate in 100 ml distilled water.

Arsenic Standard Stock Solution - Dissolve 1.320 g arsenic trioxide in 10 ml of 40% sodium hydroxide and diluted to 1 liter with distilled water. (Various strengths of standard solutions are prepared by further diluting this stock solution with suitable volumes of water, triple distilled in glass.)

Nonag - Stopcock grease, Fischer Scientific Co.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml of distilled water, flow meter and vacuum pump. Sampling rate is at 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Calibration curve - known microgram amounts of arsenic (1-15 micrograms) in the form of standard arsenic solution are pipetted into 125 ml Erlenmeyer flasks. Distilled water is added to make the total volume 35 ml. To the flasks are added 5 ml hydrochloric acid, 2 ml 15% potassium iodide solution, and 8 drops of stannous chloride solution. The flasks are swirled and allowed to stand for 15 minutes.

Three ml of the pyridine solution of silver diethyldithiocarbamate are placed in the absorbing tube, which is attached to the scrubber containing glass wool impregnated with lead acetate. (See Figure 2.)

The ground joints are lubricated with "Nonag" stopcock grease, 3 g of granulated zinc are added to the solution in the flask, and the receiving tube is inserted immediately. Arsine evolution is completed in about 30 minutes.

At the end of this time, the absorbing solution is transferred to a 1 cm square cell and the absorbance measured at 560 millimicrons in the Beckman spectrophotometer. Plotting measured absorbances against micrograms of arsenic taken produces the standard curve.

Air samples, after the previously described preparation treatment, are treated in the same manner as the standards.

(f) Calculations

Arsenic, in the form of arsine, displaces an equivalent amount of silver from silver diethyldithiocarbamate.

$$\text{mg As/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

Where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Beryllium

Source: Michigan Department of Public Health.

(a) Scope

This method describes a procedure for determining beryllium in stack gases.

(b) Auxiliary Apparatus

- Millipore filters and holder.
- Bausch & Lomb Large Littrow Emission Spectrograph or equivalent.

(c) Reagents

Platinum Internal Stock Solution - Purchase directly from Jarrell-Ash Company a 10% platinic chloride solution. This calculates out to be 57.88 mg platinum in 1 ml solution.

Platinum Internal Standard Working Solution - Pipette 1 ml of platinum stock solution containing 57.88 mg Pt per ml into a

25 ml volumetric flask, take to volume with water giving a solution containing 116 micrograms platinum/.05 ml.

Standard Beryllium Solutions:

1. Beryllium stock solution. Dissolve .0982 g of $BeSO_4 \cdot 4H_2O$ in 10 ml of redistilled 1:1 hydrochloric acid and dilute to 100 ml with distilled water. Solution contains 5.0 mg beryllium per 100 ml or 2.5 micrograms Be/.05 ml.

2. Working beryllium standard solutions. These should be prepared from the stock solution just before use. Suggested concentrations are from .003 to .5 microgram Be/.05 ml.

Nitric Acid - To clean all laboratory glassware.

(d) Sampling Procedure

Assemble sampling train of probe, millipore filter and holder, flow meter and vacuum pump. Sampling rate at 1 CFM for a period long enough to provide a minimum of 10 CF at standard conditions.

(e) Analytical Procedure

The millipore filter containing the sample is transferred to a chemically clean 125 ml beaker. The filter and sample are wet ashed with nitric acid. The residue is then dissolved in 3 ml of concentrated nitric acid and 1-2 ml of distilled water. Transfer to a graduated centrifuge tube, rinse the beaker with water and add the rinsing to the sample solution. Evaporate to a volume of 0.2 ml and if an appreciable amount of salt is present, a volume of more than 0.2 ml may be required.

The standard curve is plotted on log-log paper and micrograms Be per .05 ml is plotted versus the intensity ratio of Be 2348.6 line over Pt 2357.1 line. The standard curve is usually set up in the range of .003 microgram Be/.05 ml to .5 microgram Be/.05 ml. Six beryllium concentrations used to establish the working curve are prepared as follows:

For the first 3 concentrations, the stock solution containing 50 micrograms Be/ml is diluted 1 ml to 100 in distilled water giving a working solution of .5 microgram Be/ml.

1. .003 microgram Be/.05 ml. Pipette 1.2 ml of working standard beryllium solution (.5 microgram Be/ml) into a 10 ml volumetric flask and take to volume with water.

2. .005 microgram Be/.05 ml. Pipette 2 ml of working standard beryllium solution (.5 microgram Be/ml) into a 10 ml volumetric flask and take to volume with water.

3. .01 microgram Be/.05 ml. Pipette 4 ml of working standard beryllium solution (.5 microgram Be/ml) into a 10 ml volumetric flask and take to volume with water.

4. .05 microgram Be/.05 ml. Pipette .2 ml of stock beryllium solution (50 micrograms Be/ml) into a 10 ml volumetric flask and take to volume with water.

5. .1 microgram Be/.05 ml. Pipette .4 ml of stock beryllium solution (50 micrograms Be/ml) into a 10 ml volumetric flask and take to volume with water.

6. .5 microgram Be/.05 ml. Pipette 2 ml of stock beryllium solution (50 micrograms Be/ml) into a 10 ml volumetric flask and take to volume with water.

Spectrographic apparatus, materials and exposure conditions are as follows:

1. Optical conditions - 10 micron slit is used in the spectrograph.

2. Densitometer - Non-recording National Spectrograph Spec Reader.

3. Electrodes - Upper Electrode (cathode) United Carbon Products Company, 3/16" diameter, sharpened to a point in a regular de-leaded pencil sharpener. Lower Electrode (anode). United Carbon Products Electrode, catalog No. 100-L, 1/4" diameter, crater is 3/16" diameter and 5/32" deep.

4. Exposure conditions - 220 volts DC arc, operating at 7.5 amperes with a constant gap of 5 mm maintained between the anode and cathode, exposure time is until burn-out of lithium chloride buffer.

5. Photographic - Eastman Kodak Spectrum Analysis No. 1 Plate, developed 3.5 minutes in Eastman D-19 Developer at 68° F and fixed for 8 minutes in Eastman Koda Fixer (National Spectrographic Developing machine). Emulsion is calibrated by use of the two-step filter in front of the slit. The density of

the filter section is given by Bausch and Lomb Company, makers of the filter.

6. Nitrogen - AirCo dry nitrogen, flow rate regulated by F. W. Dwyer Manufacturing Company flow meter, maximum flow rate 6 liters per minute, regulator 3,000 pounds. The nitrogen flow around the electrode is between 3-4 liters per minute.

Preparation of the electrodes for both standard curve and sample analysis is as follows: A 1/4" diameter electrode is waterproofed by immersion in Dow Corning silicone solution (2% in acetone), and air dried for at least 30 minutes. A 10 mg charge of lithium chloride-graphite buffer is placed in the electrode and packed by tapping gently on the table top.

Into the electrodes prepared as described above is pipetted .05 ml of the platinum internal standard working solution (116 micrograms/.05 ml). The electrodes are placed in a 60° C oven and allowed to dry. Upon removal from the oven, .05 ml of the standard beryllium solution is pipetted into the appropriate electrodes. From the centrifuge tubes, where the samples have been evaporated down, is pipetted .05 ml into the appropriate electrodes. The electrodes are then returned to the 60° C oven and maintained at that temperature until dry. The temperature is then brought up to 105° C and maintained at that temperature for 1 hour. The electrodes are now removed from the oven and are ready for analysis. After the spectrograph and power supply have been set as previously described, the electrodes are placed in the respective electrode holders. The nitrogen flow is turned on and set at a rate of between 3-4 liters per minute around the lower electrode. With the shutter open during the entire exposure the arc is lit and allowed to run until burn-out of the lithium chloride buffer which is indicated by a vanishing of the red lithium color.

After the plate has been developed and dried as described previously, it is placed on the densitometer and the percent transmission set to 100 on a clear portion of the plate. The percent transmittance value of Be 2348.6 and the background adjacent to this line is read. The percent transmittance value of Pt 2357.1 line is also read. Through the use of the gamma curve the percent transmission values of the bismuth line and the background adjacent to it and the Pt line are transformed to I values and a ratio taken of I value Be 2348.6 over I value Pt 2357.1 made. Each one of the varying concentrations of beryllium standard curve and of the sample is run in triplicate and an average of these taken for the final calculation. The amount of beryllium per .05 ml sample is read from the standard curve.

(f) Calculation

$$\text{micrograms Be}/M^3 = \frac{V \cdot Y}{v . Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Cadmium

Source: Michigan Department of Public Health.

(a) Scope

Stack testing for cadmium can be accomplished by the polarograph method using a dropping-mercury electrode with the sample as the electrolyte.

(b) Auxiliary Apparatus

Sargent Polarograph - Model XXl, recording type or equivalent.

(c) Reagents

Standard Lead Solution - Dissolve approximately 25 grams of C.P. $Pb(NO_3)_2$ in minimum of hot water and cool with stirring. Filter with suction on small Buchner funnel. Repeat recrystallization. Dry crystals at 100°-110° C to constant weight, cool in desiccator and store in tightly stoppered pyrex bottle. The product has no water of crystallization and is not appreciably hygroscopic. Weigh exactly 0.1599 grams of recrystallized C.P. $Pb(NO_3)_2$, put into 500-ml volumetric flask, and take to volume with 0.1 N HCl. This gives a standard lead solution containing 200 micrograms Pb/ml with 0.1 N HCl as the electrolyte. The 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Standard Cadmium Solution - Weigh exactly 0.2744 grams of $Cd(NO_3)_2 \cdot 4H_2O$ into a 500-ml volumetric flask and take to volume with 0.1 N HCl. This gives a standard cadmium solution containing 200 micrograms cadmium per ml with 0.1 NHCl as the electrolyte. As in the lead solution the 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Oxygen Absorbent for Purification of Nitrogen - Pass nitrogen through a first scrubbing flask (a midget impinger) containing concentrated NH_4OH and copper turnings. Caution: Make certain hole in impinger is not plugged before turning nitrogen under pressure on. Then pass nitrogen through a second scrubbing flask containing concentrated sulfuric acid, again making certain this is not plugged before applying pressure.

0.2 N hydrochloric acid - Prepare this from constant boiling hydrochloric acid according to outline in Lange's Handbook.

Clean, Dry Mercury - Purchase from Eberback & Son

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml of 5% nitric acrid, flow meter and vacuum pump. Sample at rate of 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - Transfer the collecting solution from the impinger into a 250 ml beaker, wash out impinger with hot 5% nitric acid and all taken down to dryness on a hot plate. Cool and add 25 ml of 0.2 N HCl. Heat just to boiling and transfer to a 50 ml volumetric flask. Dilute to volume with distilled water which will dilute the 0.2 N HCl to 0.1 N HCl which is the electrolyte.

Transfer a 10-ml aliquot from the 50-ml volumetric flask into the polarographic cell, add 1 ml of 200 micrograms Pb per ml solution, and remove oxygen from the cell by bubbling nitrogen, which is being purified as described under reagents, through for three to five minutes. The initial voltmeter is set at .3 volts, the span voltmeter is set at .6 volts, thereby giving a range from -.3 volts to -.9 volts. This is sufficient as lead "comes off" at approximately -.44 volts and cadmium at approximately -.66 volts. The sensitivity setting might have to be found by trial and error; 0.020 suffices for most samples although if the cadmium is low the sensitivity will have to be increased (decreasing the number of microamperes/mm.).

If there is a possibility that Pb is present in the sample an aliquot of the sample should be run in the polarographic cell first, without any internal standard added. If there is Pb present in the sample, this must be taken into account when Pb, the internal standard, is added.

Standard Curve - Into the polarographic cell is introduced 1 ml of 200 micrograms Pb per ml solution, 1 ml of 200 micrograms Cd per ml solution and 9 ml of 0.1 N HCl. This gives a total amount of solution in the cell of 11 ml, thereby enabling a later removal of 10 ml of the sample and 1 ml of 200 micrograms Pb per ml internal standard solution. Also, there is an electrolyte in the cell of 0.1 N HCl. Both the volume of liquid in the cell and the electrolyte for standard curve and sample are critical for a proper analysis.

On the standard curve the heights of the Pb and Cd curves are measured in mm. The Cd to Pb ratio is found, which is divided by the number of micrograms of Cd used giving a factor for 1 microgram Cd versus 200 micrograms Pb. It is suggested that 200 micrograms Pb be used as an internal standard in each sample for Cd thereby simplifying the calculations. The factor for 1 microgram Cd versus 200 microgram Pb, found at the beginning of the series of samples being analyzed, will be used for the calculations throughout this series.

(e) Calculations

For the sample "polarogram" the heights of the Pb and Cd curves are measured in mm. and the Cd to Pb ratio found in the same manner as the standard curve. The ratio found here is divided by the factor found in the standard curve for 1 microgram Cd versus 200 micrograms Pb giving the number of micrograms of Cd in the aliquot put into the polarographic cell.

$$\text{mg Cd/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

Where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Fluoride

Source: Talvitie method modified by Michigan Department of Public Health.

(a) Scope

This method describes a procedure for determining fluoride in stack gases.

(b) Auxiliary Apparatus

- Standard impinger with fritted glass bubbler.
- 250 ml Claissen flasks.
- 100 ml Nessler Tubes.

(c) Reagents

Standard Sodium Fluoride - Make a solution containing 1 mg of fluoride per ml (2.21 g of sodium fluoride to 1 liter). Take 10 mls of this solution and dilute to 1 liter; 1 ml of this dilution contains .01 mg fluoride.

Color Forming Reagent - Dissolve 36.99 g of sodium sulfate in about 500 ml of hot distilled water and 17.7 g of sodium formate in about 200 ml of hot distilled water. Mix together and when cooled, add 0.1436 g thorium nitrate tetrahydrate and 11 ml of 90% formic acid.

Alizarin monosodium sulfonate indicator 128.25 mg dissolved in 1 liter of distilled water.

Nitric Acid - About 5 ml concentrated acid, diluted to a liter with distilled water.

Sodium Hydroxide - .5 N. (20 g dissolved in 1 liter of water).

Silver Sulfate.

Concentrated Sulfuric Acid.

(e) Sampling Procedure

Assemble sampling train of probe, impinger with fritted glass bubbler containing 100 ml of a 2% sodium hydroxide solution, flow meter and vacuum pump. Sample at a rate of 1 CFM for a period long enough to provide a minimum of 15 cubic feet at standard conditions.

(f) Analytical Procedure

Sample Preparation - Transfer the collecting solution from the impinger into a Claissen flask. Slowly add 35 ml of concentrated sulfuric acid (using small long stem funnel) to content, submerging and swirling flask in cool-cold water while adding the acid--this offsets the loss of HF. Add boiling chips and silver sulfate (to cover the end of a spatula). Close the flask with a two-hole rubber stopper, through which passes a thermometer and a 6 mm O.D. glass tube drawn to capillary size and extends down into the solution. Connect tube to a separatory funnel containing water. This is to slowly add water to both cool the flask and to replenish the water boiled off due to distillation in the Claissen flask.

The distillation flask should be placed on a pad of transite or asbestos, or on a plate of aluminum with a hole about 2 inches in diameter made to fit the flask perfectly.

Regulate the heat under the steam distillation flask so that the distillate being collected remains cool. Adjust the application of heat to the still so that a temperature of 165° C is maintained. Collect the distillate in a 250-ml volumetric flask or in a 250-ml beaker, and then make up to exactly 250 ml in a volumetric flask. Stopper the flask and mix. Pipette 25 ml into a 100-ml-long form Nessler tube. Add 5.0 ml of alizarin indicator. Titrate carefully with a .5 N sodium hydroxide until the solution changes from yellow to a decided pink. Back titrate with the dilute nitric acid until the solution changes to a pure yellow. Dilute to about 90 ml, add 3 ml of thorium reagent, make up to exactly 100 ml and mix well. After 30 minutes, compare with the standards. If the same is beyond the range of the standards, use a smaller aliquot. If it is too close to the standard containing no fluorine, double or treble the aliquot.

A blank must be carried through all the steps of the procedure, using the same amounts of reagents as are used in the samples. An aliquot of 75 ml is usually necessary to determine the amount of fluorine present in the blank.

(f) Calculations

Calculate the total amount of fluorine present in the blank and subtract this from the total fluorine found in each sample.

$$\text{mg F/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Lead

Source: Michigan Department of Public Health.

(a) Scope

Stack testing for cadmium can be accomplished by the polarograph method using a dropping-mercury electrode with the sample as the electrolyte.

(b) Auxiliary Apparatus

Sargent Polarograph - Model XX1, recording type, or equivalent.

(c) Reagents

Standard Lead Solution - Dissolve approximately 25 grams of C.P. $Pb(NO_3)_2$ in minimum of hot water and cool with stirring. Filter with suction on small Buchner funnel. Repeat recrystallization. Dry crystals at 100°-110° C to constant weight, cool in desiccator and store in tightly stoppered pyrex bottle. The product has no water of crystallization and is not appreciably hygroscopic. Weight exactly 0.1599 grams of recrystallized C.P. $Pb(NO_3)_2$, put into 500-ml volumetric flask, and take to volume with 0.1 N HCl. This gives a standard lead solution containing 200 micrograms Pb/ml with 0.1 N HCl as the electrolyte. The 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Standard Cadmium Solution - Weight exactly 0.2744 grams of $Cd(NO_3)_2 \cdot 4H_2O$ into a 500-ml volumetric flask and take to volume with 0.1 N HCl. This gives a standard cadmium solution containing 200 micrograms cadmium per ml with 0.1 N HCl as the electrolyte. As in the lead solution, the 0.1 N HCl should be prepared from constant boiling hydrochloric acid.

Oxygen Absorbent for Purification of Nitrogen - Pass nitrogen through a first scrubbing flask (a midget impinger) containing concentrated NH_4OH and copper turnings. Caution: Make certain hole in impinger is not plugged before turning nitrogen under pressure on. Then pass nitrogen through a second scrubbing flask containing concentrated sulfuric acid, again making certain this is not plugged before applying pressure.

0.2 N. Hydrochloric Acid - Prepare this from constant boiling hydrochloric acid according to outline in Lange's Handbook.

Clean, Dry Mercury - Purchase from Eberbach and Son.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml 5% nitric acid solution, flow meter and vacuum pump. Sample at rate of 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - Transfer the collecting solution to a 250-ml beaker, wash out impinger with 5% hot nitric acid and all taken down to dryness on a hot plate. Cool and add 25 ml of 0.2 N HCl. Heat just to boiling and transfer to a 50-ml volumetric flask. Dilute to volume with distilled water which will dilute the 0.2 N HCl to 0.1 N HCl which is the electrolyte.

Transfer a 10-ml aliquot from the 50-ml volumetric flask into the polarographic cell, add 1 ml of 200 micrograms Cd per ml solution, and remove oxygen from the cell by bubbling nitrogen which is being purified as described under reagents, through for three to five minutes. The instrument used is a Sargent Polarograph - Model XXI and the settings are as follows: A.C. switch down (on), D.M.E. - up (negative), Damping - down (off), Initial E.M.F. - up (additive), D.C. E.M.F. - down (1.5 V span), Chart drive - up (on), Operation - up (E.M.F. increasing). The initial voltmeter is set at .3 volts, the span voltmeter is set at .6 volts, thereby giving a range from -.3 volts to -.9

volts. This is sufficient as lead "comes off" at approximately -.44 volts and cadmium at approximately -.66 volts. The sensitivity setting might have to be found by trial and error, 0.020 suffices for most samples although if the lead is low the sensitivity will have to be increased (decreasing the number of microamperes/mm).

If there is a possibility that Cd is present in the sample, an aliquot of the sample should be run in the polarographic cell first, without any internal standard added. If there is CD present in the sample this must be taken into account when Cd, the internal standard, is added.

Standard Curve - Into the polarographic cell is introduced 1 ml of 200 micrograms Pb per ml solution, 1 ml of 200 micrograms Cd per ml solution and 9 ml of 0.1 N HCl. This gives a total amount of solution in the cell of 11 ml thereby enabling a later removal of 10 ml of the sample and 1 ml of 200 micrograms Cd per ml internal standard solution. Also, there is an electrolyte in the cell of 0.1 N HCl. Both the volume of liquid in the cell and the electrolyte for standard curve and sample are critical for a proper analysis.

On the standard curve the heights of the Pb and Cd curves are measured in mm. The Pb to Cd ratio is found, which is divided by the number of micrograms of Pb used giving a factor for 1 microgram Pb versus 200 micrograms Cd. It is suggested that 200 micrograms Cd be used as an internal standard in each sample for Pb thereby simplifying the calculations. The factor for 1 microgram Pb versus 200 micrograms Cd, found at the beginning of the series of samples being analyzed, will be used for the calculations through this series.

(f) Calculations

For the sample "polarogram" the heights of the Pb and Cd curves are measured in mm and the Pb to Cd ratio found in the same manner as the standard curve. The ratio found here is divided by the factor found in the standard curve for 1 microgram Pb versus 200 micrograms Cd giving the number of micrograms of Pb in the aliquot put into the polarographic cell.

$$\text{mg Pb/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions.

Mercury

Source: American Conference of Governmental Industrial Hygienists.

(a) Scope

Divalent mercury forms an orange-yellow complex with dithizone in dilute acid solution which can be extracted by chloroform. An additional extraction in the presence of chloride and bromide ions eliminates the interference of other metals.

(b) Auxiliary Apparatus

- Beckman DU Spectrophotometer or equivalent.
- Squibb separator funnels.
- Cuvettes.

(c) Reagents

HCl-0.1 N.

Meta Cresol Purple Indicator - Dissolve 0.05 g of the power in 6 ml of 0.05 N NaOH; then dilute to 100 ml with distilled water.

Buffer Solution - Dissolve 300 g anhydrous Na_2HPO_4 and 75 g K_2CO_3 in distilled water to make 2 liters of solution (MacIlvaine's Buffer Solutions).

Treated Chloroform - Chloroform treated with hydroxylamine hydrochloride as per the method of Hubbard, Industrial Engineering Chemistry, Anal. Ed., 9, 493 (1937).

Dithizone Solutions - Make up a stock solution containing 0.5 mg dithizone per ml of chloroform. Other strength dithizone solutions can be made up as needed. It is advisable to allow the dithizone solutions to stabilize overnight before use.

Potassium Bromide Solution - 40% KBr in distilled water.

Ammonium Citrate - 40%. Mix 40 g citric acid, monohydrate, with about 20 ml distilled water. Add sufficient ammonium hydroxide slowly with constant stirring to make solution alkaline to phenol red and make to volume with water. Purify by shaking with dithizone in chloroform and clear with pure chloroform.

Mercury Standard Solutions - Dissolve 0.1354 g mercuric chloride, C.P., special reagent grade in 1 N HCl and make up to 100 ml with the acid. This solution contains 1 mg Hg per ml and is quite stable. If any cloud or sediment develops, it should be discarded. Other strength solutions can be made by dilution with distilled water as the need arises.

Hydroxylamine Hydrochloride - 20% solution in distilled water.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml of 0.25% iodine in a 3% aqueous solution of potassium iodide. Sampling rate of 1 CFM for a period long enought to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - The contents of the impinger flask and washings are made up to a known volume with distilled water. A proper aliquot is taken to place the mercury concentration within range of the method. Add 5 ml of ammonium citrate, 1 ml hydroxylamine hydrochloride and shake. Add 2 drops of phenol red indicator. (Always add the hydroxylamine hydrochloride before the phenol red.) Titrate with ammonium hydroxide to the full color end point pH of 8.5. Extract with 5 ml portions of 20 mg/liter dithizone solution, withdrawing the chloroform layers into another 250 ml Squibb separatory funnel, into which has been placed 50 ml of 0.1 N HCl. Continue to extract with and withdraw 5-ml portions until the dithizone in the chloroform layer does not change color.

Shake the above dithizone extract with 50 ml 0.1 N HCl for 2 minutes. Draw off the chloroform into a clean separatory funnel. Wash the aqueous phase with two, 3-5 ml portions of treated chloroform and add to the extracts. Discard the aqueous phase. To the chloroform extracts, add 50 ml of 0.1 N HCl and 10 ml of the 40% KBr reagent. Shake for 2 minutes. The Hg goes into the aqueous phase as H_2HgBr_4 while the Cu and Bi remains in the dithizone which is discarded. Wash the aqueous phase with a few ml of treated chloroform. Let the phases separate well and discard completely all chloroform droplets. An aliquot of the stripping solution may be taken if necessary so that the amount of Hg will fall on the standard curve. If an aliquot is taken, make up to 50 ml volume with 0.1 N HCl.

Add 10 ml buffer solution to bring the pH to 6, and 10 ml of 10 mg/liter dithizone solution. Shake well for 2 minutes. Avoid any exposure to direct sunlight or exceedingly bright artificial light.

NOTE: If the separatory funnel was not washed thoroughly with distilled water, the dithizone may be oxidized.

By means of a cotton swab on an applicator stick, remove any traces of moisture from the stem of the funnel after the stopcock has been opened for a second to allow the chloroform to fill the bore. Loosely insert a small cotton plug in the stem of the funnel. Rinse a cuvette twice with 1-2 ml portions of the chloroform layer and draw off the remaining dithizone into the cuvette. Place in the spectrophotometer and read at point of maximum light absorption (485 millimicron) against distilled chloroform. A blank on reagents should be carried through the entire procedure and this blank subtracted from the final result.

Standard curve - Suitable concentrations of mercury to give coverage over the entire range are used to establish a particular curve. Three or four points are sufficient.

Place 5 ml of the 40% KBr reagent, 10 ml of the buffer solution and the proper amount of standard mercury solution in a 125 ml Squibb separatory funnel. Add enought 0.1 N HCl to make the final volume 65 ml. Then add 10 ml of 10 mg/liter dithizone solution and shake for 2 minutes. Flush the stem of the separatory funnel and remove moisture by means of a cotton swab, withdraw the chloroform layer and read in the spectrophotometer as described above.

The 10 mg/liter dithizone solution is of sufficient strength to cover the range from 0 to 15 micrograms of mercury. By using 20 ml instead of the standard 10 ml of this reagent, the concentration range covered can be doubled. It is not recommended to add more than 20 ml of 10 mg/liter dithizone to any sample.

For only an occasional mercury analysis, it is better to bracket the sample with standard amounts rather than prepare an entire curve.

(f) Calculation

$$\text{mg Hg/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Zinc

Source: Michigan Department of Public Health.

(a) Scope

Stack testing for zinc can be accomplished by the polarograph method using a dropping-mercury electrode with the sample as the electrolyte.

(b) Auxiliary Apparatus

Sargent Polarograph - Model XXl, recording type, or equivalent.

(c) Reagents

Stock Zinc Solution - Weigh exactly 5.0 grams of dry reagent zinc (30 mesh or finer) into a 500-ml volumetric flask and add a minimum amount of constant boiling hydrochloric acid to get the zinc in solution. Boil until solution is complete and make up to volume with distilled water. The solution contains 10.0 mg zinc per ml.

Working Standard Zinc Solution - Pipette 5.0 ml of stock zinc solution (10.0 mg zinc per ml) into 500-ml volumetric flask and take to volume with 0.2 M KCl. The solution contains 100 micrograms zinc per ml with 0.2 M KCl as the electrolyte.

0.2 M KCl Solution - Weigh 14.9 grams reagent grade KCl into 1 liter volumetric flask and take to volume with distilled water.

Standard Cadmium Solution - Weigh exactly 0.2744 grams of $Cd(NO_3)_2 \cdot 4H_2O$ into a 500-ml volumetric flask and take to volume with 0.2 M KCl. The solution contains 200 micrograms Cd per ml with 0.2 M KCl as electrolyte.

Oxygen Absorbent for Purification of Nitrogen - Pass nitrogen through a first scrubbing flask (midget impinger) containing concentrated NH_4OH and copper turnings. Caution: Make certain hole in impinger is not plugged before turning nitrogen on under pressure. Then pass nitrogen through a second scrubbing flask containing concentrated sulfuric acid, again making certain this is not plugged before applying pressure.

Clean, Dry Mercury - Purchase from Eberbach & Son.

(d) Sampling Procedure

Assemble sampling train of probe, impinger with 100 ml 5% nitric acid solution, flow meter and vacuum pump. Sample at rate of 1 CFM for a period long enough to provide a minimum of 30 cubic feet at standard conditions.

(e) Analytical Procedure

Sample Preparation - Transfer the collecting solution from the impinger into a 250 ml beaker, wash out impinger with 5% hot nitric acid and all taken down to dryness on a hot plate. Add 2 ml concentrated nitric acid, wetting the sample thoroughly. Add 6 drops perchloric acid and swirl to mix. Evaporate to dryness on a hot plate at 350°-400° C. Repeat the acid treatment to obtain complete digestion. Cool and add 10 ml of 0.2 M potassium chloride solution. Loosen the solids with a rubber policeman, rinse policeman and beaker walls with 3-5 ml of 0.2 M potassium chloride solution. Cover with a watch glass and boil 2-3 minutes. Filter the solution into a 50-ml volumetric flask washing the filter with 0.2 M KCl. Dilute to volume with 0.2 M KCl giving the sample in 50 ml with 0.2 M KCl as the electrolyte.

APPENDIX E
EXHIBIT 2

Transfer 10 ml aliquot into polarographic cell, add 1 ml of 200 micrograms Cd per ml solution, and remove oxygen from cell by bubbling nitrogen through for three to five minutes. The initial voltmeter is set at .4 volts, the span voltmeter is set at 1 volt, thereby giving a range from -.4 volts to -1.4 volts. This is sufficient as cadmium "comes off" at approximately -.66 volts and zinc at approximately -1.05 volts. The sensitivity setting will vary depending on the amount of zinc present. The setting used for the standard curve is 0.02 microamperes/mm.

If there is a possibility that Cd is present in the sample an aliquot of the sample should be run in the polarographic cell first, without any internal standard added. If there is Cd present in the sample this must be taken into account when CD, the internal standard, is added.

Standard curve - Into the polarographic cell is introduced 1 ml of 100 micrograms Zn per ml solution, 1 ml of 200 micrograms Cd per ml solution, and 9 ml of 0.2 M KCl solution. This gives a total amount of solution in the cell of 11 ml thereby enabling a later removal of 10 ml of the sample and 1 ml of 200 micrograms Cd per ml internal standard solution. Also, there is an electrolyte in the cell of 0.2 M KCl. Both the volume of liquid in the cell and the electrolyte for standard curve and sample are critical for a proper analysis.

On the standard curve the heights of the Zn and Cd curves are measured in mm. The Zn to Cd ratio is found which is divided by the number of micrograms of Zn used giving a factor for 1 microgram Zn versus 200 micrograms Cd. It is suggested that 200 micrograms Cd be used as an internal standard in each sample for Zn thereby simplifying the calculations. The factor for 1 microgram Zn versus 200 micrograms Cd, found at the beginning of the series of samples being analyzed, will be used for the calculations through this series.

(f) Calculations

For the sample "polarogram" the heights of the Zn and Cd curves are measured in mm and the Zn to Cd ratio found in the same manner as the standard curve. The ratio found here is divided by the factor found in the standard curve for 1 microgram Zn versus 200 micrograms Cd giving the number of micrograms of Zn in the aliquot put into the polarographic cell.

$$\text{mg Zn/M}^3 = \frac{V \cdot Y}{1{,}000 \cdot v \cdot Va}$$

where v = aliquot (ml)
V = total sample (ml)
Y = micrograms in v
Va = gas sample volume, in cubic meters, at standard conditions

Nitrogen Oxides, Phenoldisulfonic Acid Method

Source: Public Health Service.

(a) Scope

When sulfur dioxide, ammonia, iron or other compounds that interfere with the hydrogen peroxide method are present in the gas to be sampled and/or the concentration of the nitrogen oxides is below about 100 ppm, this method is used. Accuracy below 5 ppm is questionable. This test is unsuitable for atmospheric sampling.

(b) Apparatus

- Sampling Probe - Stainless steel (type 304 or 316) or glass tubing of suitable size (1/4-inch-OD, 6-foot-long stainless steel tubing has been used).
- Collection Flask - A 2-liter round-bottom flask with an outer 24/40 joint for integrated samples or a 250-ml MSA sampling tube for grab samples.
- Orifice Assembly - The size of the glass capillary tubing depends on the desired sampling period (flow rates of about 1 liter per minute have been used). Use of this orifice is not mandatory.
- Adapter with Stopcock - Adapter for connecting collection flask to sampling "T".
- Three-way Stopcock.

- Manometer	- A 36-inch Hg manometer or accurate vacuum gage.
- Spectrophotometer	- Beckman Model "B" or equivalent.

(c) Reagents

Thirty Percent Hydrogen Peroxide - (reagent grade).

Three Percent Hydrogen Peroxide - Dilute 30% H_2O_2 with water at 1:10 ratio. Prepare fresh daily.

Concentrated Sulfuric Acid.

0.1 N (approximate) Sulfuric Acid - Dilute 2.8 ml concentrated H_2SO_4 to 1 liter with water.

Absorbing Solution - Add 12 drops 3% H_2O_2 to each 100 ml 0.1 N H_2SO_4. Make enough for required number of tests.

1 N (approximate) Sodium Hydroximde - Dissolve 40 gm NaOH pellets in water and dilute to 1 liter.

Concentrated Ammonium Hydroxide.

Fuming Sulfuric Acid - 15 to 18 weight percent free sulfuric anhydride (oleum).

Phenol (reagent grade).

Phenoldisulfonic Acid Solution - Dissolve 25 grams of pure white phenol in 150 ml concentrated H_2SO_4 on a steam bath. Cool and add 75 ml fuming sulfuric acid. Heat to 100° C for 2 hours. Store in a dark stoppered bottle. This solution should be colorless if prepared with quality reagents.

Potassium Nitrate (reagent grade).

Standard Potassium Nitrate Solution - Solution A: Dissolve 0.5495 gram KNO_3 and dilute to 1 liter in a volumetric flask. Solution B: Dilute 100 ml of Solution A to 1 liter. One ml of Solution A contains the equivalent of 0.250 mg NO_2 and of Solution B, 0.0250 mg NO_2.

(d) Sampling Procedure

Integrated Grab Sample - Add 25 ml freshly prepared absorbing solution into the flask. Record the exact volume of absorbing solution used.

Set up the apparatus as shown in Figure 3, attach the selected orifice. Purge the probe and orifice assembly with the gas to be tested before sampling begins by applying suction to it. Evacuate the system to the vapor pressure of the solution: this pressure is reached when the solution begins to boil. Record the pressure in the flask and the ambient temperature. Open the valve to the sampling probe to collect the sample. Constant flow will be maintained until the pressure reaches 0.53 of the atmospheric pressure. Stop before this point is reached. During sampling, check the rate of fall of the mercury in one leg of the manometer in case clogging, especially of the orifice, occurs. At the end of the sampling period, record the pressure, temperature, and barometric pressure.

An extended period of sampling can be obtained by following this procedure. Open the valve only a few seconds at regular intervals. For example: Open the valve for 10 seconds and close it for 50 seconds; repeat every 60 seconds.

Grab Sample - Set up the apparatus as shown in Figure 4 for high concentrations (200-3000 ppm) or the apparatus as shown in Figure 4 for low concentrations (0-200 ppm) but delete the orifice assembly. The same procedure is followed as in the integrated method except that the valve is opened at the source for about 10 seconds and no orifice is used.

Calibration curves are made to cover different ranges of concentrations. Using a microburette for the first two lower ranges and a 50-ml burette for the next two higher ranges, transfer the following into separate 150-ml beakers (or 200-ml casseroles).

1. 0-100 ppm: 0.0 (blank), 2.0, 4.0, 6.0., 8.0, 10.0, 12.0, 16.0, 20.0 ml of KNO_3 Solution B.
2. 50-500 ppm: 0.0 (blank), 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0 ml of KNO_3 Solution A.
3. 500-1500 ppm: 0.0 (blank), 5.0, 10.0, 15.0, 20.0, 25.0, 30.0 ml of KNO_3 Solution A.
4. 1500-3000 ppm: 0.0 (blank), 15.0, 30.0, 35.0, 40.0, 45.0., 50.0, 55.0, 60.0 ml KNO_3 Solution A.

Add 25.0 ml absorbing solution to each beaker. Follow as directed in the Analytical Procedure section starting with the addition of 1 N NaOH.

After the yellow color has developed, make dilutions for the following ranges: 50 to 500 ppm (1:10); 500 to 1,400 ppm (1:20); and 1,500 to 3,000 ppm (1:50). Read the absorbance of each solution at 420 millimicron.

Plot concentrations against absorbance on rectangular graph paper. A new calibration curve should be made with each new batch of phenoldisulfonic acid solution or every few weeks.

(e) Analytical Procedure

Shake the flask for 15 minutes and allow to stand over night.

Transfer the contents of the collection flask to a beaker. Wash the flask three times with 15-ml portions of H_2O and add the washings to the solution in the beaker. For a blank add 25 ml absorbing solution and 45 ml H_2O to a beaker. Proceed as follows for the bank and samples.

Add 1 N NaOH to the beaker until the solution is just alkaline to litmus paper. Evaporate the solution to dryness on a water bath and allow to cool. Carefully add 2 ml phenoldisulfonic acid solution to the dried residue and triturate thoroughly with a glass rod, making sure that all the residue comes into contact with the solution. Add 1 ml H_2O and four drops concentrated H_2SO_4. Heat the solution on the water bath for 3 minutes, stirring occasionally.

Allow to cool and add 20 ml H_2O, mix well by stirring, and add 10 ml concentrated NH_4OH, dropwise, stirring constantly. Transfer the solution to a 50-ml volumetric flask, washing the beaker three times with 4- to 5-ml portions of H_2O. Dilute to mark with water and mix thoroughly. Transfer a portion of the solution to a dry, clean centrifuge tube and centrifuge, or filter a portion of the solution.

Read the absorbance of each sample at 420 millimicron. If the absorbance is higher than 0.6, make a suitable dilution of both the sample and blank and read the absorbance again.

(f) Calculations

$$\text{ppm } NO_2 = \frac{(5.24 \times 10^5)\ (C)}{V_s}$$

Where C = concentration of NO_2, mg (from calibration chart)

Vs= gas sample volume at 70° F and 29.92 in Hg, ml.

Sulfur Dioxide and Sulfur Trioxide, Shell Development Company Method

Source: National Air Pollution Control Administration Publication 999-AP-13.

(a) Scope

This method describes a procedure for determining sulfur dioxide and sulfur trioxide in stack gases.

(b) Apparatus

- Sampling Probe	- Glass tubing (preferably borosilicate or quartz) of suitable size with a ball joint at one end and a removable filter at the other (a 1/2-inch-OD, 6-foot-long tube has been used.)
- Filter	- A filter is needed to remove particulate matter, which may contain metal sulfates and cause interference during analysis. Borosilicate glass wool, Kaolin wool, or silica wool are suitable filters for removing particulate matter.
- Adapter	- Six plug-type connecting tubes T 24/40, one with a 90° bend and a socket joint.
- Heating Tape	- An insulated heating tape with a powerstat to prevent condensation in exposed portion of probe and adapter. Alternative: glass wool or other suitable insulators.
- Dry Gas Meter	- A 0.1-cubic-foot-per-revolution dry gas meter equipped with a fitting for a thermometer and a manometer. Alternately, a calibrated tank or a rotameter calibrated at the operating pressure may be used.
- Vacuum pump.	
- Thermometers	- One 10°-50° C, ± 1° C; and one 0°-300° C ± 5° C are suitable.
- Manometer	- A 36-inch-Hg manometer
- Absorbers	- Two U-shaped ASTM D 1266 lamp sulfur absorbers with coarse-sintered plates.

- Filter Tube	- One 40-mm-diameter Corning medium-sintered plate.
- Scrubber for Purifying Air	- An ASTM D 1266 lamp sulfur absorber with coarse-sintered plate.
- Teflon Tubing	- Teflon tubing, 1/4-inch ID, for connecting absorbers. Alternative: 8-mm pyrex tubing with butt-to-butt connections held together with Tygon.

(c) Reagents

Water - Distilled water that has been deionized.

Isopropanol, Anhydrous.

Eighty Percent Isopropyl Alcohl - Dilute isopropanol with water at a ratio of 4 to 1.

Thirty Percent Hydrogen Peroxide - (reagent grade).

Three Percent Hydrogen Peroxide - Dilute 30% hydrogen peroxide with water at a ratio of 10 to 1. Prepare fresh daily.

Barium Chloride - ($BaCl_2 \cdot 2H_2O$, reagent grade).

0.0100 N Alcoholic Barium Chloride - Dissolve 1.2216 grams $BaCl_2 \cdot 2H_2O$ in 200 ml of water and dilute to 1 liter with isopropanol. Standardize this solution with 0.01 N alcoholic sulfuric acid solution.

(As an alternate titrating solution to 0.01 N alcoholic barium chloride, in American Petroleum Institute Study Group uses 0.01 N alcoholic barium perchlorate because they believe that it gives a sharper end point during titration.)

Thorin Indicator - 1-(0-arsonophenylazo)-2 naphthol-3, 6-disulfonic acid, disodium salt.

0.2 Percent Thorin Indicator - Dissolve 0.2 gram thorin indicator in 100 ml water. Store in polyethylene bottle.

(d) Sampling Procedure

Set up the apparatus as shown in Figure 5. Place 30 ml of 80% isopropyl alcohol in the first absorber and 10 ml in the filter tube. The add 50 ml of 3% hydrogen peroxide to the second absorber. A light film of silicone grease on the upper parts of the joints may be used to prevent leakage. Wind the heating tape in a uniform single layer around the exposed portion of the probe and adapter and cover the heating tape with asbestos tape wound in the opposite direction. Place a thermometer between the heating tape and asbestos as near the adapter joint as possible. Connect the heating tape to a powerstat, switch on the current, and maintain the probe and adapter at a temperature at which no condensation will occur (about 250° C). Sample at 0.075 cubic foot per minute until 2 cubic feet or a suitable volume of gas has been sampled. Record the meter readings, temperatures and pressures at

10-minute intervals. Note the barometric pressure. Do not sample at a vacuum of more than 8 inches Hg.

Disconnect the asbestos tape, heating tape, probe, and adapter and allow them to cool. Connect the scrubber for purifying air to the inlet of the isopropyl alcohol absorber and add 50 ml of 3% hydrogen peroxide. Replace the water in the ice bath with tap water. Draw air through the system for 15 minutes to transfer residual sulfur dioxide to the hydrogen peroxide absorber. Disconnect the purifying air scrubber. (Although the use of air for removal of sulfur dioxide from isopropyl alcohol should not result in oxidation of sulfur dioxide to sulfur trioxide, the American Petroleum Institute Joint Study Group uses 99% nitrogen to preclude any possibility of oxidation.) Remove the filter and wash the probe and adapter with 80% isopropyl alcohol. Place the washings in the isopropyl alcohol absorber.

Disconnect the hydrogen peroxide absorber and transfer the contents and the water washings to a 250-ml volumetric flask. Dilute the water to the mark. Analyze for sulfur dioxide.

Stopper the isopropyl alcohol absorber and apply suction to the filter end. Remove the suction line and allow the partial vacuum in the absorber to draw the solution from the filter. Rinse the filter tube with 80% isopropyl alcohol before the suction is lost. Transfer the contents of the isopropyl alcohol absorber and its washings to a 250-ml volumetric flask and dilute to the mark with 80% isopropyl alcohol. Analyze for sulfur trioxide.

(e) Analytical Procedure

Sulfur Trioxide - Pipette a suitable aliquot to a flask and dilute to 100 ml with 80% isopropyl alcohol. Add a few drops of thorin indicator (enough to give a yellow color). Titrate with 0.01 N $BaCl_2$ to the pink end point. Make a blank determination in parallel.

Sulfur Dioxide - Transfer a suitable aliquot to a flask and add 4 times this volume of isopropyl alcohol. Dilute to 100 ml with 80% isopropyl alcohol, add enough thorin indicator to give a yellow color, an titrate with standard 0.01 N $BaCl_2$ to the pink end point. Run a blank determination in parallel.

(f) Calculations

$$\text{ppm } SO_2 \text{ or } SO_3 \text{ by volume} = \frac{24(A-B)\ (N)\ (F)\ (T)}{(V_o)\ (P)}$$

Where A = 0.01N $BaCl_2$ used for titration of sample
B = ml 0.01N $BaCl_2$ used for titration of blank
N = exact normality of $BaCl_2$
F = dilution factor
T = average meter temperature, ^oR
V_o = observed volume of gas sample, cu ft
P = average absolute meter pressure, in. Hg

APPENDIX E
EXHIBIT 2
FIGURE 1

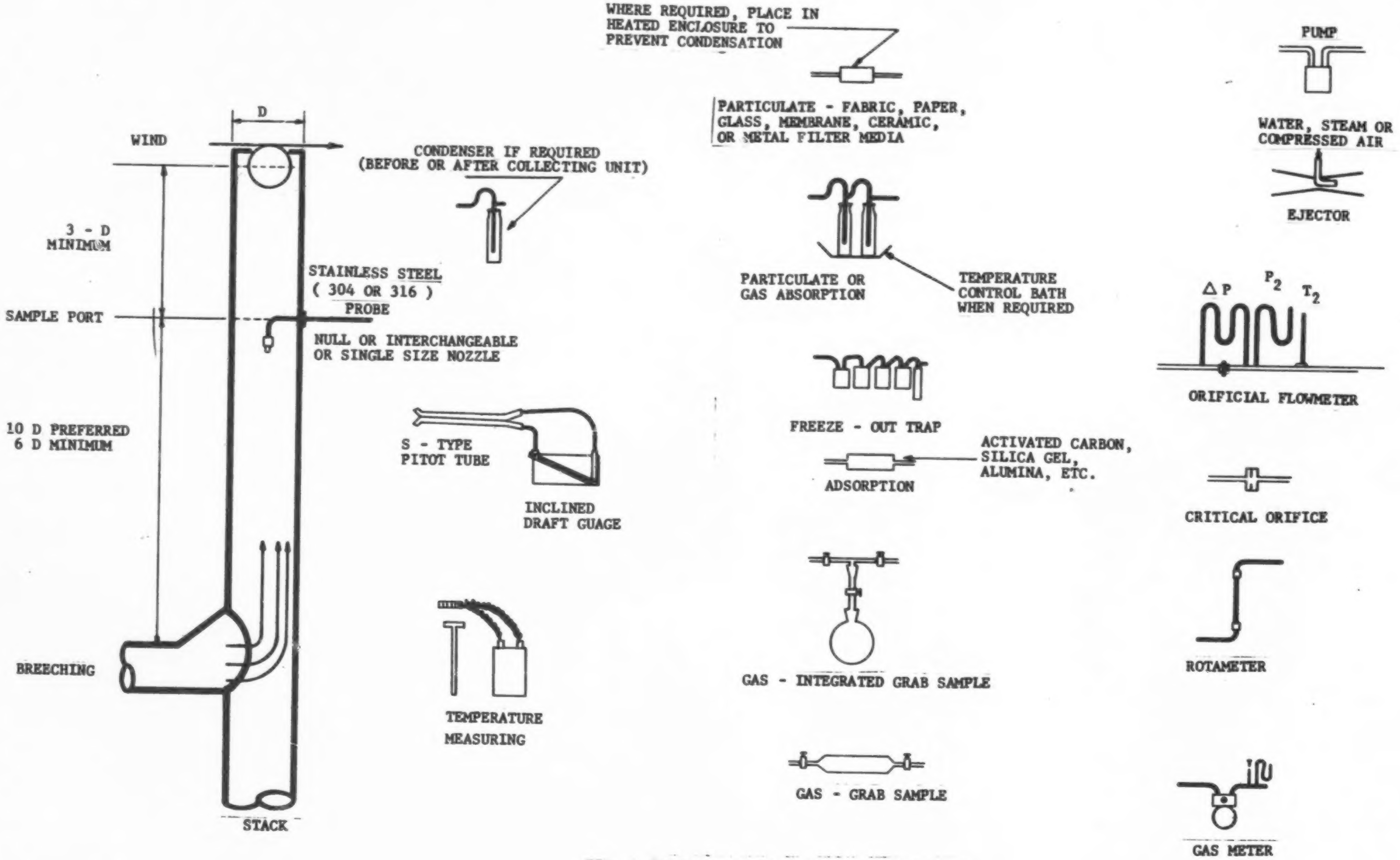
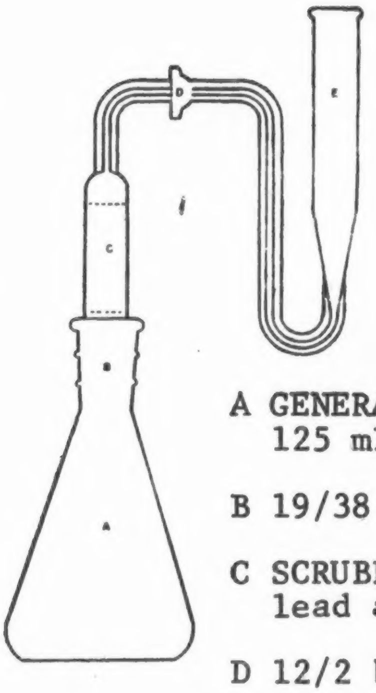

WIND
D
3 - D MINIMUM
SAMPLE PORT
10 D PREFERRED
6 D MINIMUM
BREECHING
STACK
STAINLESS STEEL (304 OR 316) PROBE
NULL OR INTERCHANGEABLE OR SINGLE SIZE NOZZLE
CONDENSER IF REQUIRED (BEFORE OR AFTER COLLECTING UNIT)
S - TYPE PITOT TUBE
INCLINED DRAFT GUAGE
TEMPERATURE MEASURING
WHERE REQUIRED, PLACE IN HEATED ENCLOSURE TO PREVENT CONDENSATION
PARTICULATE - FABRIC, PAPER, GLASS, MEMBRANE, CERAMIC, OR METAL FILTER MEDIA
PARTICULATE OR GAS ABSORPTION
TEMPERATURE CONTROL BATH WHEN REQUIRED
FREEZE - OUT TRAP
ADSORPTION
ACTIVATED CARBON, SILICA GEL, ALUMINA, ETC.
GAS - INTEGRATED GRAB SAMPLE
GAS - GRAB SAMPLE
PUMP
WATER, STEAM OR COMPRESSED AIR
EJECTOR
ΔP
P2
T2
ORIFICIAL FLOWMETER
CRITICAL ORIFICE
ROTAMETER
GAS METER

FIG. 1 SAMPLING LOCATION & TRAIN COMPONENTS

APPENDIX E
EXHIBIT 2
FIGURE 2



A GENERATOR
125 ml Erlenmeyer

B 19/38

C SCRUBBER
lead acetate on pyrex wool

D 12/2 ball joint

E ABSORBER
12 ml heavy wall
centrifuge tube

FIGURE 2

Arsine Generator

APPENDIX E
EXHIBIT 2
FIGURES 3 & 4

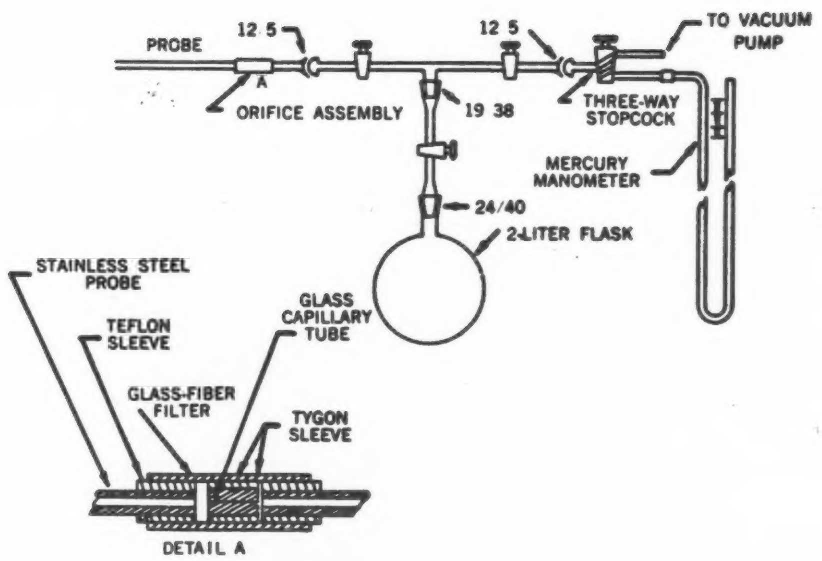

PROBE
12 5
A
ORIFICE ASSEMBLY
19 38
12 5
TO VACUUM PUMP
THREE-WAY STOPCOCK
MERCURY MANOMETER
24/40
2-LITER FLASK
STAINLESS STEEL PROBE
TEFLON SLEEVE
GLASS CAPILLARY TUBE
GLASS-FIBER FILTER
TYGON SLEEVE
DETAIL A

FIGURE 3

APPARATUS FOR INTEGRATED GRAB SAMPLES

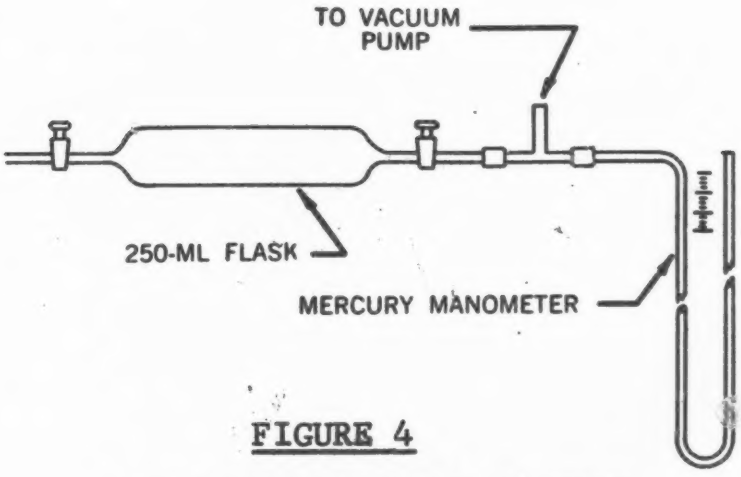

TO VACUUM PUMP
250-ML FLASK
MERCURY MANOMETER

FIGURE 4

APPARATUS FOR GRAB SAMPLES

APPENDIX E
EXHIBIT 2
FIGURE 5

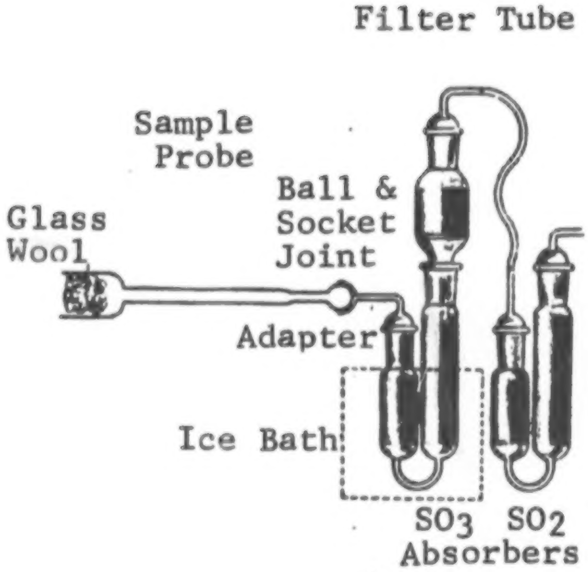

Filter Tube
Sample Probe
Ball & Socket Joint
Glass Wool
Adapter
Ice Bath
SO3 SO2
Absorbers

FIGURE 5

Sulfur dioxide - sulfur trioxide sampling train.

GLOSSARY OF TERMS

ACFM -	Actual cubic feet per minute; refers to the volume of gas at the prevailing temperature and pressure.
Acid Lining -	A refractory furnace lining essentially of silica.
Additive -	A substance added to another in relatively small amounts to impart or improve desirable qualities, or suppress undesirable qualities. As additives to molding sand, for example, cereal, sea coal, etc.
Aerosol -	Small particles, liquid or solid, suspended in the air. The diameters vary from 100 microns down to 0.01 microns or less; for example, dust, fog, smoke.
Afterburner -	A device for burning combustible materials that were not oxidized in an initial burning process.
Agglomeration -	Gathering together of small particles into larger particles.
Air Cleaner -	A device designed for the purpose of removing atmospheric airborne impurities such as dusts, gases, vapors, fumes and smokes.
Air Filter -	Any method used to remove gases and particulates from the environment and stack emission; it may be of cloth, fibers, liquid spray, electrostatic, etc.
Air Furnace -	A reverberatory-type furnace in which metal is melted by heat from fuel burning at one end of the hearth, passing over the bath toward the stack at the other end.
Air Pollution -	The presence in the outdoor atmosphere of one or more air contaminants or combinations thereof in such quantities and of such duration that they are or may tend to be injurious to human, plant or animal life, or property, or that interfere with the comfortable enjoyment of life or property or the conduct of business.
Anneal -	A heat treatment which usually involves a slow cooling for the purpose of altering mechanical or physical properties of the metal, particularly to reduce hardness.

Baghouse -	A large chamber for holding bags used in the filtration of gases from a furnace to recover metal oxides and other solids suspended in the gases. It's a form of dust collector and the bags may be constructed of natural, synthetic, or glass fibers.
Baked Core -	A core which has been heated through sufficient time and temperature to produce the desired physical properties attainable from its oxidizing or thermal setting binders.
Balanced Blast -	Arrangement of tuyeres in a cupola which provides for distributing or balancing the blast as required between upper and lower levels of the melting zone.
Basic Lining -	In a melting furnace, the inner lining and bottom composed of materials that have a basic reaction in the melting process, usually either crushed burned dolomite, magnesite, magnesite bricks or basic slag.
Bed -	Initial charge of fuel in a cupola upon which the melting is started.
Blast -	Air driven into the cupola furnace for combustion of fuel.
Blast Volume -	The volume of air introduced into the cupola for the burning of fuel. This volume governs the melting rate of the cupola and approximately 30,000 cubic feet of air is required per ton of metal melted.
Briquette -	Compact cylindrical or other shaped block formed of finely divided materials by incorporation of a binder, by pressure, or both. Materials may be ferroalloys, metal borings or chips, silicon carbide, coke breeze, etc.
Burden -	A collective term of the component parts of the metal charge for a cupola melt.
Burned Sand -	Sand in which the binder or bond has been removed or impaired by contact with molten metal.
Canopy Hood -	A metal hood over a furnace for collecting gases being exhausted into the atmosphere surrounding the furnace.

Cantilever Hood -	A counterbalanced hood over a furnace that can be folded out of the way for charging and pouring the furnace.
Cast Iron -	Essentially an alloy of iron, carbon and silicon in which the carbon is present in excess of the amount which can be retained in solid solution in austenite at the eutectic temperature.
Catalytic Combustion -	A device for burning combustible gases, vapors, aerosols and odorous substances, reducing them to water vapor and carbon dioxide.
Centrifuging -	A method of casting, employing a core and depending on centrifugal force to make the metal more dense and strong in the outer portion of the casting. The mold cavities are usually spaced symmetrically about a central sprue, and the whole assembly is rotated about that axis during pouring and solidification.
Cereal Binder -	A binder used in core mixtures and molding sands, derived principally from corn flour.
Charge -	The total ore, ingot, metal, pig iron, scrap, limestone, etc. introduced into a melting furnace for the production of a single heat.
Charging Door -	An opening in the cupola or furnace through which the charges are introduced.
Coke -	A porous gray infusible product resulting from the dry distillation of bituminous coal, which is used as a fuel in cupola melting.
Coke Breeze -	These are fines from coke screenings.
Convection -	The motion resulting in a fluid from the differences in density and the action of gravity due to temperature differences in one part of the fluid and another. The motion of the fluid results in a transfer of heat from one part to the other.
Cope -	The upper or topmost section of a flask, mold, or pattern.
Core -	A separate part of the mold which forms cavities and openings in castings which are not possible with a pattern alone. Cores are usually made of a different sand from that used in the mold and are generally baked or set by a combination of resins.

Core Binder -	Any material used to hold the grains of core sand together.
Core Blower -	A machine for making cores by blowing sand into the core box by means of compressed air.
Core Oven -	Specially heated chambers for the drying of cores at low temperatures.
Core Sand -	Sand for making cores to which a binding material has been added to obtain good cohesion and porosity after drying.
Crucible -	A vessel or pot made of a refractory such as graphite or silicon carbide with a high melting point and used for melting metals.
Cupola -	A cylindrical straight shaft furnace usually lined with refractories, for melting metal in direct contact with coke by forcing air under pressure through openings near its base.
Cupola, Hot Blast -	A cupola supplied with a preheated air blast.
Cupola Stack -	The overall top column of the cupola from the charging floor to the spark arrestor.
Cyclone - (centrifugal collector)	A device with a control descending vortex created to spiral objectionable gases and dusts to the bottom of a collector cone for the purpose of collecting particulate matter from process gases.
Cyclonic Scrubber -	Radial liquid (usually water) sprays introduced into cyclones to facilitate collection of particulates.
Density -	Ratio of the weight of gas to the volume, normally expressed as pounds per cubic foot.
Desulfurizing -	The removal of sulfur from molten metal by the addition of suitable compounds.
Direct Arc Furnace -	An electric arc furnace in which the metal being melted is one of the poles.
Drag -	The lower or bottom section of the mold, flask or pattern.

Ductile Iron -	Iron of a normally gray cast type that has been suitably treated with a nodularizing agent so that all or the major portion of its graphitic carbon has a nodular or spherulitic form as cast.
Duplexing -	A method of producing molten metal of desired analysis. The metal being melted in one furnace and refined in a second.
Dust -	Small solid particles created by the breaking up of larger particles by processes such as crushing, grinding, drilling, explosion, etc.
Dust Collector -	An air cleaning device to remove heavy particulate loadings from exhaust systems before discharge to outdoors.
Dust Loading -	The concentration of dust in the gas entering or leaving the collector, usually expressed as pounds of particulate per 1,000 pounds of dry gas or grains per standard cubic foot.
Efficiency -	With regard to dust collectors, it is the ratio of the weight of dust trapped in the collector to the weight of dust entering the collector. This is expressed as a percent.
Effluent -	The discharge entering the atmosphere from the process.
Electrostatic Precipitator-	A dust collector utilizing a high voltage electrostatic field formed by negative and positive electrodes; the positive, uncharged electrode attracts and collects the gas-borne particles.
Elutriation -	The sizing or classifying of particulate matter by suspension in a fluid (liquid or gas), the larger particulates tending to separate by sinking.
Emission -	The total pollutants emitted into the atmosphere usually expressed as weight per unit of time such as pounds per hour.
Endothermic Reaction -	Designating, or pertaining to a reaction which occurs with the absorption of heat from the surroundings.
Equivalent Opacity -	The determination of smoke density by comparing the apparent density of smoke as it issues from a stack with a Ringelmann chart. In effect, it is a measure of the light obscurity capacity of the plume.

Exothermic Reaction -	Chemical reactions involving the liberation of heat; such as burning of fuel and deoxidizing of iron with aluminum.
Fabric Filter -	A dust collector using filters made of synthetic, natural or glass fibers within a baghouse for removing solid particulate matter from the air or gas stream.
Facing Sand -	Specially prepared molding sand mixture used in the mold adjacent to the pattern to produce a smooth casting surface.
Fines -	A term the exact meaning of which varies. 1. Those sand grains that are substantially smaller than the predominating grain size. 2. That portion of sieved material that passes through the mesh.
Flask -	Metal or wood frame without top or without fixed bottom used to retain the sand in which a mold is formed; usually consists of two parts, cope and drag.
Flux -	Material or mixture of materials which causes other compounds with which it comes in contact to fuse at a temperature lower than their normal fusion temperature.
Fly Ash -	A finely divided siliceous material, usually oxides, formed as a product of combustion of coke. A common effluent from the cupola.
Forehearth -	Brick lined reservoir in front of and connected to the cupola or other melting furnaces for receiving and holding the melted metal.
Foundry Effluent -	Waste material in water or air that is discharged from a foundry.
Fourth Hole Ventilation - (Direct Tap)	In air pollution control, using a fourth hole in the roof of an electric furnace to exhaust fumes.
Fume -	A term applied to fine solid particles dispersed in air or gases and formed by condensation, sublimation, or chemical reaction.

Gas -	Formless fluids which tend to occupy entire space uniformly at ordinary temperatures and pressures.
Gate -	The portion of the runner in a mold through which molten metal enters the mold cavity.
Gray Iron -	Cast iron which contains a relatively large percentage of its carbon in the form of graphite and substantially all of the remainder of the carbon in the form of eutectoid carbide.
Green Sand -	A naturally bonded sand or a compounded molding sand mixture which has been tempered with water and additives for use while still in a damp or wet condition.
Griffin System -	A method operating in two stages, to recoup and preheat air by using the latent heat of cupola gases.
Heat Balance -	A determination of the sources of heat input and the subsequent flow of heat usually expressed in equation form so that heat input equals heat output.
Heat Treatment -	A combination of heating and cleaning operations timed and applied to a metal or alloy in the solid state in a manner which will produce desired properties.
Heel -	Metal left in ladle after pouring has been completed. Metal kept in induction furnaces during standby periods.
Holding Furnace -	A furnace for maintaining molten metal, from a larger melting furnace, at the proper casting temperature.
Hood -	Projecting cover above a furnace or other equipment for purpose of collecting smoke, fume or dust.
Hot Blast -	Blast which has been heated prior to entering into the combustion reaction of a cupola.
Indirect Arc Furnace -	An electric arc furnace in which the metal bath is not one of the poles of the arc.
Induction Furnace -	A melting furnace which utilizes the heat generated by electrical induction to melt a metal charge.
Inlet Volume -	The quantity of gas entering the collector from the system it serves (in cubic feet per minute at a specified temperature).

Inoculant -	Material which when added to molten metal modifies the structure changing the physical and mechanical properties of the metal.
Inoculation -	The addition to molten metal substances designed to form nuclei for crystallization.
Ladle Addition -	The addition of alloying elements to the molten metal in the ladle.
Latent Heat -	Thermal energy absorbed or released when a substance changes state; that is, from one solid phase to another, or from solid to liquid or the like.
Lining -	Inside refractory layer of firebrick, clay, sand or other material in a furnace or ladle.
Magnesium Treatment -	The addition of magnesium to molten metal to form nodular iron.
Malleable Iron -	A mixture of iron and carbon, including smaller amounts of silicon, manganese, sulfur and phosphorous, which, after being cast as white iron, is converted structurally by heat treatment into a matrix of ferrite containing nodules of temper carbon, and substantially free of all combined carbon.
Material Balance -	A determination of the material input to the cupola and the output to fully account for all material.
Melting Rate -	The tonnage of metal melted per unit of time, generally tons per hour.
Micron -	A unit of measurement which is 1/25,000 of an inch or a millionth of a meter. Often designated by the Greek letter mu.
Mist -	Visible emission usually formed by a condensation process or vapor-phase reaction, the liquid particles being sufficiently large to fall of their own weight.
Mold -	The form, usually made of sand, which contains the cavity into which molten metal is poured to produce a casting of definite shape and outline.
Muller -	A type of foundry sand mixing machine.

Nodular Cast Iron -	(See Ductile Iron)
Opacity -	The state of a substance which renders it partially or wholly impervious to rays of light. Opacity as used in an ordinance refers to the obscuration of an observer's view.
Outlet Volume -	Quantity of gas exhausting from the collector (in cubic feet per minute at a specified temperature).
Oxidizing Atmosphere -	An atmosphere resulting from the combustion of fuels in an atmosphere where excess oxygen is present, and with no unburned fuel lost in the products of combustion.
Oxidation Losses -	Reduction in amount of metal or alloy through oxidation. Such losses usually are the largest factor in melting loss.
Particulate Matter -	Solid or liquid particles, except water, visible with or without a microscope, that make up the obvious portion of an exhaust gas or smoke.
Parting Compound -	A material dusted, brushed or sprayed on patterns or mold halves to prevent adherence of sand and to promote easy separation of cope and drag parting surfaces when cope is lifted from drag.
Pattern -	A form made of wood, metal or other materials around which molding material is placed to make a mold for casting metals.
Plume -	A visible, elongated, vertical (horizontal when windblown) column of mixed gases and gas-borne particulates emitted from a smoke stack.
Pollutant -	Any foreign substance in the air or water in sufficient quantities and of such characteristics and duration as to be injurious to human, plant, or animal life or property, or which unreasonably interferes with the enjoyment of life and property.
Preheater -	A device used to preheat the charge before it is charged into the furnace.
Process Weight -	The total weight of raw materials, except air, introduced into any specific process, possibly causing discharge into the atmosphere.
Recuperator -	Equipment for transferring heat from hot gases for the preheating of incoming fuel or air.
Reducing Atmosphere -	An atmosphere resulting from the incomplete combustion of fuels.

Refractory -	Heat resistant material, usually nonmetallic, used for furnace linings, etc.
Reverberatory Furnace -	A large quantity furnace with a vaulted ceiling that reflects flame and heat toward the hearth or the surface of the charge to be melted.
Ringelmann's Scale - (chart)	A system of optical charts reading from all clear to solid black for grading the density of smoke emissions.
Riser -	An opening in the top of a mold which acts as a reservoir for molten metal and connected to the casting to provide additional metal to the casting as it contracts on solidification.
Rotary Furnace -	A furnace using pulverized coal, gas or oil; of cylindrical shape with conical ends, mounted so as to be tipped at either end to facilitate charging, pouring and slagging.
SCFM -	Units standing for Standard Cubic Feet per Minute. The volume of gas measured at standard conditions, one atmosphere of pressure and 70° F.
Sea Coal -	A term applied to finely ground coal which is mixed with foundry sands.
Sensible Heat -	That portion of the heat which changes only the temperature, but does not cause a phase change.
Shakeout -	The operation of removing castings from a sand mold.
Shell Molding -	A process for forming a mold from thermosetting resin bonded sand mixtures brought in contact with preheated metal patterns, resulting in a firm shell with a cavity corresponding to the outline of the pattern.
Shotblasting -	Casting cleaning process employing a metal abrasive propelled by centrifugal force.
Slag -	Nonmetallic covering which forms on the molten metal as a result of the flux action in combining impurities contained in the original charge, some ash from the fuel and silica and clay eroded from the refractory lining.

Smoke -	A type of emission resulting from incomplete combustion and consisting predominantly of small gas-borne particles of combustible material present in sufficient quantity to be observable independently of the presence of other solids in the gas stream.
Spark Arrestor -	Device over the top of the cupola to prevent the emission of sparks.
Sprue -	The channel, usually vertical, connecting the pouring basin with the runner to the mold cavity. In top pour casting the sprue may also act as a riser.
Standard Air -	Air with a density of .075 pounds per cubic foot, generally equivalent to dry air at 70° F and one atmosphere of pressure (14.7 psia).
Superheating -	Heating of a metal to temperatures above the melting point of the metal to obtain more complete refining or greater fluidity.
Tapping -	Removing molten metal from the melting furnace by opening the tap hole and allowing the metal to run into a ladle.
Tuyere -	The nozzle openings in the cupola shell and refractory lining through which the air blast is forced.
Vapor -	The gaseous form of a substance normally in the solid or liquid state and which can be returned to these states either by increasing pressure or decreasing temperature.
Ventilation System -	In the foundry, the exhaust ventilation and dust control equipment for the health, safety, comfort and good housekeeping of those who work there.
Venturi Scrubber -	In air pollution control, a high velocity gas stream directed into the throat of a venturi of a wet scrubber to separate out particulates.
Wet Cap -	A device installed on a cupola stack that collects emissions by forcing them through a curtain of water. The device requires no exhaust fan but depends upon the velocity pressure of the effluent gases.

Wet Scrubber - In air pollution control, a liquid spray device, usually water, for collecting pollutants in escaping foundry gases.

Wind Box - The chamber surrounding a cupola through which air is conducted under pressure to the tuyeres.